PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A63B 53/04	A1	(11) International Publication Number: WO 99/24124 (43) International Publication Date: 20 May 1999 (20.05.99)

(21) International Application Number: PCT/US98/23219

(22) International Filing Date: 4 November 1998 (04.11.98)

(30) Priority Data:
60/064,605 7 November 1997 (07.11.97) US

(71) Applicant (*for all designated States except US*): TEARDROP GOLF COMPANY [US/US]; 8350 North Lehigh Avenue, Morton Grove, IL 60053 (US).

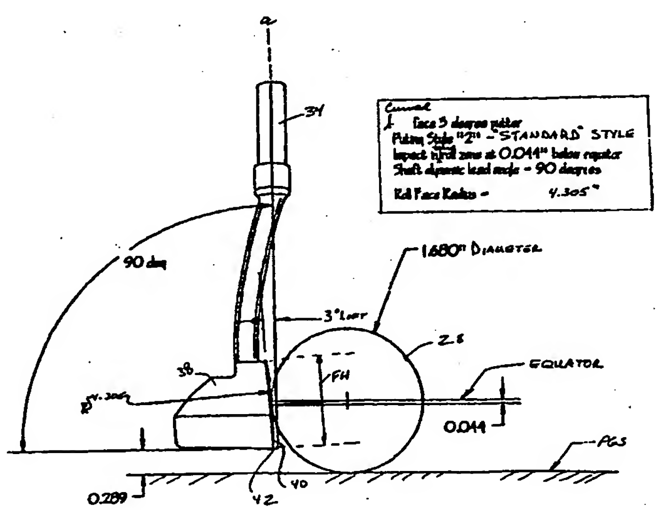
(72) Inventors; and
(75) Inventors/Applicants (*for US only*): SLUCKER, Rudy [US/US]; 66 Duffield Drive, South Orange, NJ 07079 (US). REED, Timothy, R. [US/US]; 140 Glen Road, Hawthorne, IL 60047 (US). ZERAVICA, John [US/US]; 224 East Center Avenue, Lake Bluff, IL 60044 (US).

(74) Agent: HOFFMAN, Richard, B.; Tilton, Fallon, Lungmus & Chestnut, 100 South Wacker Drive, Chicago, IL 60606-4002 (US).

(81) Designated States: AU, CN, GB, JP, RU, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: GOLF PUTTER WITH IMPROVED CURVED STRIKING FACE, PUTTER SYSTEM, AND METHOD OF MAKING SAME



(57) Abstract

An improved vertically-curved strike face (15) for a golf putter, the roll radius for which is determined based on the given strike face height and loft selected, wherein, regardless of a given golfer's putting stroke style, and of variations within that stroke style, the improved curved strike face (15) as determined permits consistently impacting the golf ball (28) in a critical true roll zone just slightly above the equator. Custom-fitting, to accommodate a given golfer's extreme putting style, or a given course's daily Stimpmeter™ reading, or green speed or mowed putting green conditions, can be achieved by selecting a given curved strike face loft and the resultant strike face roll radius. A basic form of the invention comprises a series of putters with different roll radius, for a given loft and strike face height.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

GOLF PUTTER WITH IMPROVED CURVED STRIKING FACE, PUTTER SYSTEM, AND METHOD OF MAKING SAME

Reference to Related Application

This is a full and complete application based on Provisional Patent Application Serial No. 60/064,605, filed November 7, 1997, and also a Continuation-in-Part Application therefrom.

Field of the Invention

This invention relates to golf club putters having curved strike faces, and more particularly to an improved curved strike face which accommodates variances in putting styles, while assuring consistent impact of the golf ball below the ball's equator.

Background of the Invention

Numerous attempts have been made to produce putters with vertically curved strike faces which are intended to assist in assuring that putted balls run true to the target. Curved-faced putters can be full cylindrical-shaped putter heads, or formed with a face being only a portion of a cylinder. Some curved face putters have a curved striking face having a radius much larger than that of the golf ball. The typical golf ball's diameter is 1.68 inches, although more recently there are both larger balls at 1.72 inches in diameter, and smaller balls at 1.64 inches in diameter. However, such large-radiused curved face putters, by hitting above the ball's equator, tend to initially drive the ball down into the putting surface, thus causing it to hop and skip for an extended initial portion of its motion.

At the other end of the spectrum, there are curved face putters having a face radius that is substantially smaller than that of the typical golf

ball, e.g., see U.S. Patent Nos. 4,872,684, 5,193,806, 5,433,441, and 5,501,461. However, with those small-radiused putters, the strike face's contact point with the golf ball often occurs substantially below the ball's equator. This again creates unnecessary extra "hopping" and initial skidding motion for the putted ball. Thus, the ball is again caused to go substantially off line, thereby resulting in missed putts, especially in mid-length longer putts of from, say, 5 feet and beyond.

Yet other curved face putters are formed with a face radius of such a diameter as to attempt hitting the golf ball at substantially the ball's equator, e.g., see U.S. Patent Nos. 5,597,364 and 5,688,189. Also, the curved strike face of some curved-faced putters (i.e., of the partial cylinder face-type) has a built-in or static loft. A change in such loft can dramatically change the point of impact with the ball, relative to the ball's equator. Thus, with many of the curved faced putters, whatever the radius, problems result when no initial slight lift is given the ball, i.e., to cause it to rise up to, and then start rolling across, the tops of the grass blades of the putting surface.

Additionally, there is always the problem of exactly how the putter club head is delivered, i.e., presented, by the golfer's swing at impact to the golf ball. For example, it is known that a majority of golfers utilize a so-called pendulum stroke (i.e., putting style Class II), whereby the shoulders, upper arms, lower arms, wrists and hands are all locked in a given position. In that fashion, when the locked portions of one's upper torso are swung, there results a pendulum type swing motion. With that motion, the

putter shaft is delivered at impact at 90° bottom dead center to the golf ball (thereby delivering the measured static loft designed in the putter's strike face).

Further, there is another putting style, namely the so-called "broken wrist" putter stroke style (Class I), such as used by professional golfer Bobby Locke. With that particular putting stroke, the golfer causes the wrists to break just prior to impact. In effect, this acts to tilt the club head ahead of the wrists, i.e., it is moved to the left ahead of the hands at impact for a righthanded golfer. The result is that, at impact, the leading edge of the club head is actually higher off the putting surface and coming up towards the golf ball. This putting style dynamically increases the designed static loft to the putter's strike face at impact.

Further yet, there is the third or so-called "forward press" or "piston type" putting stroke style (Class III), such as used by the well known professional golfer Tiger Woods. In that putting style, the golfer's wrist and hands are so aligned as to be located, rather than over the ball at address, somewhat forward of the ball. For a righthanded golfer, the hands have moved to the left ahead of the ball at impact. With a typical flat faced putter that has designed static loft on the strike face (say, 3°), such a forward press putting style has the effect of both delofting the putter strike face at the point of impact, i.e., dynamically reducing the static loft, and also of lowering the putter head towards the putting surface, wherein the club's leading edge is closer to the ground at impact.

Since the above varied putting stroke styles

can vary so widely, it is found that, for example, with a typical flat-faced putter having a 3° of static loft, the actual dynamic loft (i.e., at impact) of the strike face can vary anywhere from -7° to +13°, i.e., the shaft impact angle can vary by ±10°. Curved face putters, however, have not previously been made to accommodate all those well known different putting styles.

Further, some prior curved face (and other type) putters have recognized the desirability of hitting the golf ball at a point below the ball's equator. This is done so as to give loft to the ball and to purportedly give it overspin or top spin. However, none of these prior putters have recognized a) that there is, in fact, a critical range for the distance below the equator to hit the golf ball, so as to minimize the initial skidding of the putted golf ball, and to therefore permit the ball's inherent angular rotation to control ball-tracking accuracy at the earliest point, and b) that roll radius determinations as a function of face height and loft can be made to assure impacting the ball within that critical range.

Further yet, there continues to be a problem with selecting the putter's appropriate roll radius, depending on the given grass conditions (i.e., speed and height) of the putting surface. That is, there is a need to accommodate the very short putting grass used in a professional golf tournament, a somewhat longer grass height used at most private country clubs and better public courses, and finally, relatively longer grass used for the putting surfaces at most public golf courses. Thus, there has been no prior correlation for selecting a curved face putter of

proper roll radius as depending on a given course's Stimpmeter reading for playing on a given day.

Summary of the Invention

The present invention overcomes the above-described problems of the prior art by providing a curved face putter that, regardless of a given golfer's putting stroke style, will consistently permit impacting the golf ball within a specific true roll impact zone below the ball's equator. That is, it is found that the best impact zone is slightly below, i.e., from only 0.015 inch to 0.073 inch below, the ball's equator, such that if the ball is hit there, initial skidding is minimized and the earliest true roll is created for the putted ball. Thus, as a function of club strike face height, and depending on the specific loft needed (whether for a professional, low amateur or high amateur golfer, or alternatively, to accommodate the day's given Stimpmeter reading) the curved strike face is formed with a resulting specific radius, thereby giving a curved strike face that will permit consistently hitting the golf ball just slightly below its equator and within the preferred true roll impact zone.

Claims abound for many prior curved face putters that their curved strike faces, upon contact with a golf ball, would immediately cause it to have overspin and start rolling true, i.e., without any unwanted initial skidding (which can then translate into severe misalignment throughout the putted ball's roll). However, actual testing has shown that there will always be an initial hopping and skidding portion to a putted ball's roll.

Thus, the goal of the present invention is to minimize that initial skidding to be no more than

10-12% of the overall putt, thereby substantially increasing the accuracy of straight line tracking of the golf ball through use of the present curved face putters. This is accomplished in the more advanced form of the invention, by varying the curved face's roll radius, depending on the putter face height, to permit impacting the ball in its true roll impact zone, regardless of putting stroke style being used.

In a more basic version of the invention, a series of similarly lofted putters, each having a different curved strike face radius, is provided. There, the golfer can choose the one curved face radius deemed most appropriate, i.e., with the best feel, for the golfer's specific putting stroke style or given green conditions.

Additionally, a system for fitting a golfer, having a specific putter stroke style or for specific green conditions, is provided. There, instead of being concerned with a particular lie angle as per the prior art, the golfer is fitted for his or her particular dynamic shaft impact angle, i.e., that shaft angle relative to the ball during impact, that results from the golfer's particular putting style.

Finally, there is provided a curved face putter that can be dynamically fitted to a given golfer, by providing a different loft depending on the height and type of the putting surface present, i.e., either for the actual mowed grass height and green speed or for the day's Stimpmeter reading, for a given course.

Brief Description of the Drawings

The means by which the foregoing and other features and aspects of the present invention are accomplished and the manner of their accomplishment

will be readily understood from the following specification upon reference to the accompanying drawings, in which:

FIG. 1 is a rear elevation view of a curved face putter made in accordance with the more basic version of the present invention;

FIG. 2 is a front elevation view of the putter of FIG. 1;

FIG. 3A is a toe end view of the putter of FIG. 1, as formed with a relatively long roll radius for the curved striking face;

FIG. 3B is a toe end view, similar to FIG. 3A, but formed with a more intermediate length radius for the curved strike face;

FIG. 3C is yet a further toe end view, also similar to FIGS. 3A and 3B, but formed with yet a shorter length roll radius for the curved strike face;

FIG. 4 is a top plan view of the putter of FIG. 3C; FIG. 5 is an illustration showing ball movement, plus accompanying definitions and equations, for determining true roll of a putted golf ball relative to the more advanced form of the invention;

FIG. 6 is a chart giving true roll test data for a lofted putter;

FIG. 7 is a graphical representation of the true roll test data of FIG. 6;

FIG. 8 is a chart with accompanying equations for calculated best line fit data for the true roll test data of FIGS. 6 and 7;

FIG. 9 is a graphical representation of the best line fit data of FIG. 8;

FIG. 10 is a graph of loft versus pure roll displacement, to determine the true roll zone for a

putted golf ball;

FIG. 11 is a graphical representation of a golf ball and the preferred true roll impact zone thereon;

FIG. 12 depicts a flat faced lofted putter, when used with putting style 1;

FIG. 13 depicts a flat faced lofted putter, when used with putting style 2;

FIG. 14 depicts a flat faced lofted putter, when used with putting style 3;

FIG. 15 depicts a curved face lofted putter, with a curved striking face made in accordance with the present invention, when used with putting style 1;

FIG. 16 depicts a curved face lofted putter, with a curved striking face made in accordance with the present invention, when used with putting style 2;

FIG. 17 depicts a curved face lofted putter, with a curved striking face made in accordance with the present invention, when used with putting style 3;

FIG. 18 is a graphical representation, plus equations, for determining the proper curved face roll radius, for variations in putter face height, in accordance with the present invention;

FIG. 19 represents, for a given loft and face height of curved face putter, the resulting roll radius;

FIGS. 20A-20E are charts listing the optimum curved face roll radii versus face height, calculated in accordance with the present invention;

FIG. 21 is a chart summarizing curved face roll radius versus loft angle;

FIG. 22 is a graph representing the roll face calculations of the chart of FIG. 21;

FIG. 23 depicts the positioning of the

center of curvature for producing a given roll radius on a curved face putter, to accommodate specific putting styles and/or putting green conditions;

FIG. 24 is a toe end view of a putter of an alternate form of the present invention; and

FIG. 25 graphically depicts the portions of multiple curvature on the strike face of the putter of FIG. 24.

Detailed Description of the Preferred Embodiment

Having reference to the drawings, wherein like reference numerals indicate corresponding elements, there is shown in FIGS. 1-5 an illustration of a basic form of the invention. It concerns providing different curved face roll radii for a putter of a given face height and which is lofted, to create different striking characteristics, depending on a given golfer's putting desires and conditions. The additional FIGS. 6-23 depict a more complete and advanced form of the invention, to provide the required optimal roll radii, for any given height of curved face putter, to assure hitting the ball consistently within its preferred true roll impact zone below the ball's equator, regardless of the putting stroke style used by a given golfer, and regardless of tolerances from normal for that golfer's own putting style.

A. Basic Form of the Invention

The present invention, in its more basic form, and in a first instance, relates to a putter head that has the shapes and features generally as shown in the drawings attached hereto. This form of the invention is first depicted in three basic embodiments as represented by FIGS. 3A, 3B, and 3C. Without minimizing the novel contributions of other

shapes and features of the depicted putter head, the putter head of the present invention is characterized, in each of its preferred embodiments, by a curved and lofted ball-striking face. This characteristic combination of both a vertically-aligned or roll radius on the striking face and a loft to the face is believed to be a unique combination of features for any putter.

The invention, in a second instance, again relative to its more basic form, involves a multiple-putter putting system that is comprised of a plurality of individual putters, each individual putter having a curved striking face defined by a radius different from that of each other putter of the plurality. Preferably, the component putters of the putter system of the present invention are those of the present invention mentioned in the "first instance" above. However, each of the putters of the plurality is not simply an alternate embodiment of the invented putter but rather, is one component putter of a putting system wherein each component putter is selectively constructed with unique striking face radius in order to provide a different striking characteristic, i.e., feel to the golfer for a given putting surface.

With reference to the drawings (especially FIGS. 3A-3C, and FIG. 4), and in an effort to better define the loft and radius of the curved striking face of the putter head, the putter of the basic form of the present invention is seen as having a ball-striking face 15, a base 16 which includes a forward planar surface 17 and a rearward surface 18, and a top surface 19. The curved strike face 15 intersects the top surface 19 at a top/forward edge 21 (referred to in profile of FIGS. 3A-3C as the "hinge point" 21).

When defining the curved face and the loft, in accordance with the preferred embodiments of the basic form of the present invention, a "loft line" 23 (seen in profile in FIGS. 3A-3C) is drawn from hinge point 21 to the line representing the plane of the bottom forward planar surface 17, such that the loft line 23 and the extension of the bottom planar surface intersect (at a "theoretical edge point" 25) to define a desired angle (see angle "α") which is equal to 90° plus the loft angle. For example, as seen in FIG. 3A, the loft angle would be 3° (that is, a 3 degree static loft). Once the theoretical edge point 25 is ascertained, each of the respective curved front strike faces 15A, 15B, and 15C is established by choosing the desired radius and making the curved strike face be the arc of the circle formed by that radius as defined by the chord from point 21 to point 25. The center of curvature of the arc of the respective curved strike faces 15A, 15B, and 15C lies, preferably, on the perpendicular bisector of the chord from point 21 to point 25.

As previously mentioned, FIGS. 3A-3C show three exemplary component putters in the multiple-putter system of the basic form of the present invention, formed of specific dimensions, and of a constant face height (see reference letter FH in FIG. 2). More particularly, the putter of FIG. 3A has a curved striking face 15A formed of a 10 inch roll radius, the putter of FIG. 3B has a curved striking face 15B formed of a 4 inch roll radius, and the putter of FIG. 3C has a curved striking face 15C formed of a 2 inch roll radius. In one set of samples in accordance with this basic form of the invention, each putter preferably has a strike face height FH of

approximately .965 inch.

Thus, the plurality of putters in the system of putters of the more basic form of this invention are represented by the three end view drawings (FIGS. 3A, 3B, and 3C). While a top view (FIG. 4) is shown for only one of the curved strike faces, namely that putter of FIG. 3C, it is understood that the top view of each of the other component putters of the system (e.g., putters of FIGS. 3A and 3B) would have a similar top view, except for the dimensional difference that would be created by the different roll radius curvature of the striking face 15 of the respective putter.

Thus, it is seen that a curved face putter of a given face height can be formed with a given loft to the curved face, and that different roll radii for the curved face can be used, whereby any one of several, or a system of lofted, curved strike face putters can be made for, selected and used by a given golfer.

B. Advanced Form of the Invention

Keeping in mind the above-described ability and resulting benefits to form a curved face putter having the combination of a given loft and roll radii, there is a further need to determine the best roll radii and loft, for a given putter design, i.e., for a putter with a given face height, so that the earliest true roll of the putted ball will consistently occur. More specifically, there has been a need to determine what roll radius, and what loft angle, is best for a given curved face putter having a known strike face height, all to minimize the initial skidding and hopping of a putted ball, to thereby achieve the earliest true roll for the ball, and to do so

regardless what putting stroke style a given golfer may use.

A series of tests were undertaken using as a standard a flat face putter having a 3° positive loft, to determine the earliest point at which so-called "true roll" began for a putted golf ball. Timed high speed photographs were utilized to establish the ball's motion, i.e., displacement position and angular rotation. It was determined that, contrary to statements made in various prior art patents, and both from the laws of physics, and from the actual timed photographs taken in connection with the present invention, an immediate true roll of a putted ball is not possible. That is, there will always be some initial portion of the ball's motion where slipping, sliding, and hopping will occur. However, there then comes a point when the ball's center and the ball's surface move together at the same rate, to establish a true roll for the ball.

In FIG. 5 there are listed various general equations and definitions for determining the true roll of a putted golf ball. (Such definitions, equations, and relationships, as set forth in FIG. 5, and in all the other accompanying Figures, are incorporated herein by reference.) For testing purposes, and as the golf ball generally utilized when playing golf by both professionals and amateurs alike, the chosen golf ball had a circumference of 1.68 inches, and thus a radius of .84 inch, plus a circumference of 5.27 inches. Thus, by definition, once a ball during its putted trajectory has moved a distance of 5.27 inches, plus during that same time rotated a full 360°, then slip page has stopped and a condition of true roll has been achieved. The present

invention's goal, therefore, is to provide a curved face putter where such a "no slip" condition, i.e., where Vc (velocity at the center of the golf ball 28, in inches/second) is the same as Vs (velocity at the surface of the golf ball 28, in inches/second), consistently occurs at the earliest possible time after impact by the putter.

By way of explanation, in the timed test photographs, the ball's distance between centers were photographed at 1/30th of a second. The photographs were taken from the side of the golf ball 28, so that the ball's movement (in both the horizontal or "X" direction and in the vertical or "Y" direction) could be recorded. The golf balls were putted with a mechanical putting device, so as to assure consistency in putting stroke style, delivered putting speed and force at impact, plus a uniform height of the putter's leading edge from the ground or putting surface.

The calculations utilized to determine the putted ball's velocity at center Vc, as well as velocity at surface Vs, are shown in FIG. 5. The two positions of the golf ball 28 as depicted in that Figure shown (in the left view) the position of the golf ball 28 at a first point, and at another given point (in the right view) just 1/30th of a second later. More specifically, FIG. 5 depicts in general how the ball's surface BS has travelled from position 1 to position 2, while the ball's center BC has been moved a distance d (in inches). Also depicted is the ball's angular rotation, represented by reference letters "ANG" (in degrees of rotation). Then, sequentially, from ball position 2 to 3, position 3 to 4, and so forth, the timed test photographs depicted the ball's actual center velocity Vc and surface

velocity Vs. Again, a condition of "no slip", and thus true roll, for the putted golf ball 28 occurred when the absolute angle of rotation was 360° and the ball's center moved 5.27 inches.

For such timed photograph putting tests, a multiple series of 10 ft. putts were made with the mechanical putting device (not shown). (A length of 10 feet was selected for such putter testing, since the great majority of putts in a round of golf are ten feet or less, such that the accuracy of such putts contribute the greatest to one's overall golf score.)

Figure 6 then represents the recorded motion data for golf ball 28, as moving from ball positions 1 through 12, for one such series of tests. As seen there, for a flat-faced putter having a measured or static face loft of 3° positive, the ball 28 has moved in the X displacement direction some 12.75 inches before the angle of rotation was 360°, even though the actual or total "no slip angle" of rotation is 869.7°, and thus, where Vs began to approximate Vc.

The surface velocity Vs is seen to increase, then slow down, then increase, then slow down, and finally increase; those changes in Vs represent the times when the putted golf ball has hopped off and then recontacted the putting surface. Similarly, the Y direction displacement figures in FIG. 6 show the correlation to such "elevated" or hopping motion of golf ball 28, i.e., when the ball hops off the putting green surface PGS during the initial portion of any putted stroke. More specifically, in FIG. 6 (see Y displacement column), figures above .84 inch reflect that the golf ball 28 is at that moment airborne by some small amount. It also reflects that true roll of

ball 28 does not occur until the ball's center finally settles at .84 inches above the PGS, i.e., the ball's lowermost surface is contacting PGS, and Vs merges towards and finally equals Vc.

Figure 7 represents a graphical plotting, again for a 3° lofted flat face putter, of the surface velocity Vs and the center velocity Vc of golf ball 28, as taken from the test results set forth in FIG. 6. As seen there, from an X displacement running from the initial impact point, i.e., at 0.0 inches, to an X displacement of approximately 12 to 13 inches, the surface velocity Vs gradually increases from 0 to approximately 22 to 23 inches per second. Similarly, over that same time, the ball's center velocity Vc gradually decreases from approximately 40 inches per second to approximately 22 to 23 inches per second. Again, this data verifies that contrary to prior assumptions and claims, there will always be some initial skidding portion to a putted ball's motion.

Figure 8 represents the calculated "best line fit" data for the true roll test results set forth in FIG. 6, and as also plotted in FIG. 7. More specifically, that Figure tabulates the calculated best line fit for both the ball's surface velocity Vs and its center velocity Vc. That figure also helps explain that, when the surface velocity Vs finally equals the center velocity Vc, the ball has achieved so-called true roll, i.e., that condition where both the ball's surface velocity and center velocity are travelling at the same speed. It will be understood that this is the point in a putted ball's motion where it has the highest moment of inertia due to achieving uniform angular acceleration, i.e., stability. This, in turn, allows the moving ball to track its putted

course with the best accuracy. However, as seen, this high moment of inertia condition (at true roll) is quite contrary to the initial portion of the putted ball's motion, wherein the initial hopping, skidding, and sliding combine to result in the ball having a much lower angular acceleration. As known, the longer the initial skidding motion continues, the greater the tendency the ball 28 has to go off line, such as when it hits any minor defects in, or small debris on, the putting green surface PGS.

Figure 8 also indicates that, for the test data of FIG. 6, true roll for ball 28 is achieved at an X horizontal displacement location of 14.456 inches. Again, at that displacement location, both Vs and Vc were equalized at 27.8 inches per second, and thereafter decay at the same rate due to gravity and friction. Thus, as seen, for a given 10 ft. putt, some 12.05% of the ball's putted motion was in initial skid, while the remaining 87.95% was in the desired true roll.

The calculated best-line-fit data of FIG. 8 is depicted in graphical form in FIG. 9. Again, it is seen that the center velocity Vc starts, at the ball's impact, at 42.0294 inches per second, and then gradually reduces, i.e., slows down, to 27.8 inches per second. At the same time, the surface velocity Vs goes from 0.0 inches per second at impact to 27.8 inches per second at the time true roll is achieved, i.e., when Vc and Vs finally merge. Again, such true roll is seen to occur at 14.456 inches after the point of impact along the putted line.

Figure 10 represents tests wherein the flat-faced putter's loft was progressively changed, versus the previous tests' use of a consistent 3° static loft

(depicted in FIGS. 6-10). That is, the flat faced putter (not shown) had its strike face loft varied, starting from 0° through 10°, in 2° increments, during testing. The resulting graph of FIG. 10, for such loft variation tests, shows the correlation between the putter's strike face loft and true roll, i.e., that X displacement when the putted ball first achieved true roll. As seen, a so-called "true roll zone" for a putted ball optimally occurs when the putter's dynamic loft, i.e., that loft being presented by the strike face at impact, falls within the range of from 2° to 4° positive loft. In that loft range, the initial skidding portion of a putted ball's motion is kept to a minimum -- thereby to achieve true roll at the earliest time and earliest displacement into the putted ball's motion. Stated another way, the unwanted initial skidding and hopping of a putted ball, before true roll finally sets in, is kept to an absolute minimum when the putter strike face is provided with a very minimal positive loft, to thereby provide the ball with only a slight upward motion, i.e., lifted just to the top of the blades of grass, so as to start true roll at the earliest moment possible.

Ideally, if every golfer could consistently deliver a 3° lofted flat face putter at generally 90° to the ground, that would insure that the golf ball 28 would be hit at an impact point at a very slight distance below the golf ball's equator to assure minimal skidding and optimum true roll. However, that often does not occur, especially in view of different putting stroke styles used, plus a golfer's variations within his or her own putting stroke.

Again, Figure 10 explains why the best "true

roll impact zone" of the club head as being below the ball's equator, i.e., so as to produce the earliest true roll, is for a putter with a loft of from 2°to 4°. Depending on the putting green speed conditions, a loft of, say, 1° positive, or instead of 5° positive, might be used. Through calculations then, one can determine the optimum impact point to hit a golf ball below its equator. That is, one uses the equation of: sin (loft) times ball's radius. For example, Sin (2°) x .84" indicates that a 2° lofted putter would hit the ball 28 at a point approximately .0293" below its equator. Similarly, Sin (4°) x .84" indicates that a 4° lofted putter would impact the ball 28 at approximately .0586" below its equator. For 1° loft, it would be 0.015 inch, and for 5° loft, it would be 0.073 inch below the ball's equator. The optimal or 3° lofted putter, would impact a ball at just .044" below its equator, to best achieve earliest true roll. (See FIG. 11.)

Thus, optimal true roll occurs when a ball is struck at a point within a true roll impact zone ranging from 0.015 inch to 0.073 inch below the ball's equator. That impact zone is where the putter's strike face should consistently impact the golf ball 28 to best achieve early true roll of the ball, no matter what putting style is used. (See FIG. 11.)

It will be understood, however, that it is very difficult for a golfer to consistently deliver a lofted flat-faced putter at a given dynamic shaft impact angle relative to the ground. ("Shaft impact angle" is intended to describe that angle between the putter's shaft centerline, and a plane through the ball and normal to the ground or putting surface, measured at impact of the club strike face with the

golf ball.)

On the other hand, by using the present invention's improved curved face putter, its strike face's roll radius can be so specially chosen as to consistently allow the curved strike face, regardless of the putting stroke style used, to hit the ball within the above-described preferred true roll impact zone. Figure 11 depicts such a true roll impact zone for the ball 28.

The dynamic impact effect of the three basic putting stroke styles, as used by both professional and amateur golfers alike, is shown in FIGS. 12-14. More specifically, FIG. 13 reflects use of putting stroke style II, or the more standard pendulum putting stroke. Here, a standard 3° lofted flat-faced putter, when delivered via putting stroke style II, causes the strike face 30 to impact ball 28, at the bottom dead center of the stroke, at an impact point some 0.44 inch below the ball's equator, i.e., within the true roll zone. The resultant dynamic shaft impact angle (caused by that putting stroke style II) for shaft 34 is 90°. Also, the lower leading edge 36 of strike face 30 is (for most golfers using style II) normally maintained at approximately 0.289 inches from the putting surface PGS. But if the club head is not exactly delivered at 90° bottom dead center, the impact point will noticeably change. Further, use of a flat faced putter does not take into consideration the slight variations that a given golfer has around his "average" putting stroke style. For example, it has been noted that a given golfer can have as much as ±2° to 3° variation, i.e, tolerance, in dynamic shaft angle around his or her average putting style.

Figure 12 shows use of putting style I, or

the so-called "broken wrist" putting style. There, the 3° static lofted flat strike face 30, when delivered to the golf ball 28, impacts the ball at a much greater distance below its equator, namely by some 0.116 inch. This occurs because the effective dynamic loft of the strike face is now 8°, or stated another way, the dynamic shaft angle is only 85°. (It will be understood here that a club's dynamic loft at impact equals 90°, less the dynamic shaft angle, plus the club's static loft.) Because of putting style I, i.e., where the wrists are broken, the club head 30 starts to rotate upwardly just prior to impact. Thus, as seen in FIG. 12, the lower leading edge 36 of the club face 30 is more elevated than with the other putting styles, i.e., elevated by some .389 inch off the putting surface GGS.

Finally, FIG. 14 depicts putting stroke style III, or the so-called "forward press" or "piston type" putting stroke style. With this particular stroke, again with a 3° lofted flat-faced putter, the putter head 32 is on a downward arc when strike face 30 impacts the golf ball 28. This downward arc, in effect, acts to reduce or deloft the static loft built into strike face 30 at impact. As seen, the strike face 30 impacts the golf ball 28 at a point some 0.029 inch above (not below) the equator of ball 28. That impact point, of course, is well out of the preferred true roll zone as described above. Moreover, due to this forward press putting style, the effective dynamic loft of the strike face is -2°, dynamic shaft angle is approximately 95°, and the leading lower edge 36 is positioned substantially lower than that of putting styles 1 or 2, namely at only some 0.189 inch from the putting surface PGS.

Thus, as seen per FIGS. 12-14, a flat face putter head 32 impacts the golf ball 28 at a point within the true roll zone (i.e., within 0.015 inch to 0.073 inch below the ball's equator) only when putting style II is used. Yet this occurs only when the 3°lofted putter is stroked such that the shaft's dynamic impact angle is truly 90°, and no variations in that shaft impact angle have been produced by the golfer. This may help explain why many professional golfers, and many low handicap amateurs, actually bend their putter's hosel, i.e., the point of attachment of the putter head to the shaft, in order to achieve a built-in static loft to counteract their final hand position at impact. Further, many golfers, and particularly amateurs, are not willing to make such changes to an expensive putter, or even know how to do so. Thus, they suffer continuously from inaccurate putting. Again, it is seen that when lofted flat-faced putters are used with either putting style I (broken wrist) or style III (forward press), they simply do not normally permit hitting the golf ball within the preferred true roll zone, and further, when used with putting style II, such flat-faced putters do not help with a golfer's own variations in his or her dynamic shaft impact angle.

Thus, there is shown in FIGS. 15 through 17 the present improved putter, generally denoted by reference numeral 38, with improved curved strike face 40. Face 40 is formed of a specific face roll radius, for a given face height, to permit consistently hitting the golf ball within the preferred true roll zone, regardless of the putting stroke style that is utilized. First, FIG. 15 depicts an improved putter 38, with improved curved strike face 40 having a 3°

positive loft, as used with putting stroke style I. As seen, that "broken wrist" style of putting still provides a dynamic lead angle of 85° for shaft 34, and causes the leading edge 42 of curved strike face 40 to still be maintained at approximately 0.389 inch above the putting surface PGS. However, because of the improved curved strike face 40, having a specific roll radius of approximately 4.305 inches, that curved face 40 assures proper impact of the ball 28 within its true roll zone, namely at approximately 0.044 inch below the ball's equator.

Second, FIG. 16 depicts the same improved curved face putter 38, but here as used with a pendulum putting stroke (i.e., style II). Here again, the curved strike face 40 is so formed on putter head 38 as to have 3° of positive loft, the dynamic lead angle is 90° for shaft 34, and the lower leading edge 42 is again maintained at 0.289 inches off the putting surface PGS. However, because of the improved curved strike face 40 (again formed with approximately a 4.305 inch roll radius), the putter head 38 was able to impact the golf ball 28 within the preferred true roll zone, namely at approximately 0.044 inches below the ball's equator.

Third, FIG. 17 shows the same 3° lofted curved face putter 38, with a curved strike face 40 again having a roll radius of 4.305 inches, but as used with the forward press putting stroke (style III). As with the flat face putter, the curved face putter head 38 is so delivered to the ball 28 that a dynamic lead angle of 95° is created for shaft 34, and the lower leading edge 42 at impact of the ball is at approximately only 0.189 inch from the putting surface PGS. However, due to the presence of the 4.305 inch

roll radius for curved strike face 40, the club head 38 yet again impacts ball 28 within the true roll zone, namely at a point 0.044 inch below the ball's equator.

As seen, not only does the present invention's improved curved face putter accommodate all three putting styles, but it is also able to accommodate a given golfer's individual variations, i.e., dynamic shaft angle tolerance, within his or her own putting style.

In FIGS. 15-17, the height of curved strike face 40 is designated by reference letters FH. It is seen that by selecting a uniform roll radius for curved strike face 40 (and one which is approximately 4.305 inches), the resulting club head 38, as formed with a 3° loft, and regardless of putter stroke style, can be used to consistently impact the golf ball within its true roll impact zone, all so as to achieve the earliest true roll for the ball 28. Further, regardless of where the curved face 40 actually impacts the golf ball 28 -- whether at a more elevated or less elevated point along the face -- such that the distance of leading edge 42 from the putting surface PGS is raised or lowered relative to the positions shown in FIGS. 15-17, the curved strike face 40 (by being of a radius of 4.305 inches) will still impact ball 28 at a point approximately 0.044 inch below the ball's equator. This consistently occurs, because of the curvature selected, i.e., roll radius, for a putter of a given face height and loft, to result in the improved curved strike face 40.

It will be understood that the strike face height FH was held constant for the putter head 38 depicted in each of FIGS. 15-17. In one sample made

in accordance with the present invention, that face height FH was selected to be .900 inch. However, such face height can also vary dramatically, depending on the specific putter design being used, whereupon in accordance with the present invention, face roll radius will necessarily change.

A progression of calculations needed to determine the correct roll radius for the curved strike face 40 are set forth in FIG. 18. More specifically, item A is the Sin (Loft) x (.5 FH), h is the chord height, B is the vertical height from leading edge to center of face, C is Tan (Loft) (A), and FH means the club's strike face height (as measured normal to the loft plane of the curved strike face 40). Use of these equations and those per FIG. 18 results in the required roll radius for a given face height FH, and wherein the X and Y dimensions delineate where the center of curvature must be to create the arc that results in the present invention's improved lofted and curved strike face 40.

For example, when such using equations, for a club head 38 having a 3° positive loft and a face height FH of approximately 1 inch, the resultant preferred roll radius is 4.783 inches. The X location is 4.777 inches, and the Y location is .250 inch, for the center of curvature.

Depicted in Figure 19, and for reference purposes, is the equation for determining a curved face roll radius for a 3° lofted putter. That is, the specific roll radius for such a putter equals face height FH times slope (i.e., 4.782), plus the Y intercept dimension, i.e., 0.00116667 inch. There is also shown in FIG. 19 a chart, created through that equation (again specifically for a 3° lofted curved

face putter), of a whole series of face heights (ranging from .500 inch to 1.500 inch), and each resultant face roll radius.

Yet a more complete and progressive listing of the optimum curved face roll radii for a widely-varying series of given face heights is set forth in the series of Figures 20A through 20E. There, for a given,i.e., selected, loft angle and face height, and per the calculations previously shown (see FIG. 18), the resultant roll radii are given, again to result in earliest true roll of the putted ball. As seen, one can use the charts given in FIGS. 20A-20E to create the particular roll radius for a given design putter head, i.e., as having a given face height FH. For example, for a loft angle of 2° and a face height of 1 inch, the roll radius is calculated as 7.168 inches. Similarly, again for a face height of 1 inch but now of a different loft angle, namely of 4°, the roll radius is determined to be only 3.593 inches. Similar such face height and loft selections, and resultant roll radii, can be readily made by reference to FIGS. 20A-20E.

A summary chart for the roll radius for a given face height putter is given in FIG. 21. In that Figure, the loft angle runs from 0.5° loft to 8.5°, for face heights running from 0.5 inches to 1.5 inches. The resulting data permits the clubmaker to pick the desired roll radius, for a given loft and face height of putter, to thereby permit the golfer, regardless of putting stroke style used (i.e., style I, II, or III) to consistently impact the golf ball below its equator within the preferred true roll zone.

Additionally, FIG. 21 can be interpreted to

permit selection of a given roll radius depending on the loft required for specific types of green conditions, i.e., grass cutting height and greens speed. For example, loft angles ranging from 0° to 2° positive loft could be used to select the roll radius that best accommodates a prototypical professional golf tournament putting green surface. This would allow a true roll impact zone of from approximately 0.015 inch to 0.044 inch below the ball's equator. On the other hand, lofts ranging from 2° to 4° could be used for selecting the roll radius that best accommodates the typical country club and better public course green conditions. This would permit a true roll impact zone of from approximately 0.024 inch to 0.059 inch below the ball equator. This would permit a true roll impact zone of from approximately 0.024 inch to 0.059 inch below the ball's equator. Further, lofts ranging from 3° to 5° could be used to select the roll radius to accommodate green conditions of higher mowed height surfaces, such as are found at most public golf courses. Here, the true roll impact zone would be from approximately 0.044 inch to 0.073 inch below the ball's equator. As can be noted, the ideal static loft would be 3° positive.

The summary chart data of Figure 21 is represented graphically in FIG. 22. That Figure better illustrates how roll radius changes substantially, as a function of loft angle, to result in a curved strike face putter of the correct roll radius to consistently allow hitting the golf ball within the true roll zone below its equator.

<u>C. Custom Fitting of Curved Face Putters</u>

In view of the foregoing basic and advanced forms of the invention, it will be understood that it

is possible to custom-fit a given golfer with a curved faced putter of a specific roll radius to accommodate a chosen specific putter design, i.e., face height, or an extreme putting style (i.e., one outside of either standard forward press or broken wrist styles), or for specific Stimpmeter (trademark) readings, i.e., for fast, medium, or slow greens. That is, once a golfer's given putting style is determined, the type putting greens that are present, and the particular face height of putter that is desired, then the specific static loft and roll radius can be calculated to custom-fit the golfer with a curved face putter.

Take for example, an extreme forward press type golfer, who desires a putter with, say, a 1.2 inch face height, and will be putting on extremely fast greens (i.e., best suited to have a 1-2° static loft). By using the charts of FIGS. 20A-20E, an optimum roll radius of 11.464 inches can be utilized. That radius is substantially different, however, than the 3.455 inch roll radius that would be used for a different forward press type golfer who, for the same face height club, actually has a much less severe forward press putting style, and is putting on slow greens, (i.e., where 5°loft is suitable). In each situation however, each forward press type golfer will have a putter (with a given custom-made, curved face roll radius) that will permit consistently impacting the golf ball within the true roll zone just slightly below the ball's equator.

Further yet, via the foregoing fitting approach, a particular golfer can even be selectively custom-fit to have a curved face putter with a sufficient roll radius to accommodate various heights of putting surfaces, i.e., grass heights or green

speeds, or various Stimpmeter (trademark) readings. For example, operators of professional golf tournaments normally have the putting surfaces relatively fast and mowed to a very short level, i.e., from approximately .125 to .156 inch. On the other hand, private country clubs and some of the better public courses have somewhat average speed, i.e., higher mowed putting grass surface, namely, cut to approximately from .156 to .281 inch; whereas most public courses have slower and yet much higher mowed putting surfaces, namely, ones cut to approximately from .172 to .281 inch.

Figure 23, in conjunction with the X and Y dimensions of the charts of FIGS. 20A to 20E, shows that, not only does the curved strike face 40 have a roll radius that is specific for a given Stimpmeter reading, but also provides the coordinates (in the X and Y dimensions) for creating that roll radius, i.e., cutting it on the clubhead to achieve a given loft. For example, a curved face putter for a professional tour putting surface might require from 1° up to a 3° loft, while a country club surface might use a 2-4° loft, and a public course might require a 3° to 5°, or higher, lofted curved face putter. Importantly, the X and Y dimensions thus reflect the center of curvature for the determined roll radius.

Figures 24 and 25 depict a modified version of the more advanced form of the improved curved face putter of the present invention. There, the curved strike face 44 is shown as having a principal or operative roll radius R_1, for generally the lower major striking portion of face 44, an upper roll radius R_2, for generally the upper non-striking portion of face 44, and a lowermost or yet third roll

radius R_3, essentially forming the lower leading edge 46 of the putter 48. As seen, the primary striking roll radius R_1 is much larger than that of upper (or so-called "aesthetic") roll radius R_2. Preferably, strike roll radius R_1 extends within the range of from 45% to 85% of the lower height of curved strike face 44; and most preferably, strike roll radius R_1 extends for approximately the lower 75% of the height A of face 44 (see FIG. 25). Conversely, upper aesthetic roll radius R_2 only extends for the upper 15% to 40% of height of strike face 44, or preferably for only approximately 25% of the upper height A in FIG. 25. As discussed above, the desired length of strike roll radius R_1 is calculated per FIG. 18, and taken from the charts of FIGS. 20A-20E, while the normally shorter length of upper roll radius R_2 can range from approximately 0.125 inches to infinity (i.e., be essentially a flat face). The locations of the respective roll radii R_1, R_2, and their respective centers of curvature are depicted in FIG. 25, where R_1 is shown as being 4.60 inches, and upper roll radius R_2 is shown as 0.800 inch, for example.

The reasons behind selecting a specific strike roll radius R_1 are as given above regarding the improved curved face of the embodiment of FIGS. 6-23. However, the reason for the additional or upper roll radius R_2, to be generally much smaller than strike roll radius R_1, is to allow the aesthetic look of the putter 48 (to the golfer's eye, including at the ball address position) to have a more visually pronounced curved face look, i.e., than would otherwise be the case if only radius R_1 were formed on strike face 44. That is, relative to the embodiment of FIGS. 6-23, the strike roll radius R_1 may be of such a larger

dimension that the strike face 44, while curved, nevertheless generally appears flat. The presence of upper radius R_2 helps soften that appearance, and gives a more curved look to the golfer's eye.

Also, the upper radius R_2 is present to allow the golfer at address with the ball (not shown) to better see the top portion of strike face (i.e., along the vertical curved area generated by roll radius R_2) and also see where the strike roll radius R_1 starts (see generally point "X" in FIGS. 24 and 25). Finally, the lower radius R_3 is simply to provide a smooth transition for curved face 44 into the club's sole 50.

From the foregoing, it is believed that those skilled in the art will readily appreciate the unique features and advantages of the present invention over previous types of curved face putters. Further, it is to be understood that while the present invention has been described in relation to particular basic and advanced embodiments, and putter systems, as set forth in the accompanying drawings and as above described, the same nevertheless are susceptible to change, variation and substitution of equivalents without departure from the spirit and scope of this invention. It is therefore intended that the present invention be unrestricted by the foregoing description and drawings, except as may appear in the following appended claims.

WE CLAIM:

1. The method of forming an optimal vertically curved strike face for a golf putter, for allowing the curved strike face to consistently impact the golf ball at a point within the ball's true roll impact zone in a range from approximately 0.015 inch to 0.073 inch below the ball's equator, and regardless of the putting stroke style used by a given golfer, comprising the steps of:

a) selecting a putter design having a given strike face height;

b) selecting a static loft for the curved strike face based on the putting green speed condition; and

c) calculating the required roll radius for the curved strike face, as based on the selected face height and static loft, to allow impacting the ball within the true roll impact zone, using the equations of:

(1) "A" = sin (static loft) (0.5) (face height)

(2) "C" = tan (static loft) (A)

(3) $h = \sqrt{A^2 + C^2}$

(4) $\text{Diameter} = \dfrac{(h^2 + (0.5\ \text{face height})^2)}{h}$

(5) $\text{Curved Radius} = \dfrac{\text{Diameter}}{2}$

wherein A, C, and h are as set forth in FIGURE 18 of the DRAWINGS.

2. The method of claim 1, and wherein the selected static loft falls within the range of from approximately 1° to 5° positive.

3. The method of claim 1, and wherein the resulting dynamic loft delivered to the golf ball at impact falls within the range of from approximately 2°

to 4° positive.

4. The method of claim 1, and wherein the selected static loft is so custom selected that, for use with relatively fast greens having a mowed grass height of from approximately 0.125 inch to 0.156 inch, the resultant putter's curved strike face static loft is from approximately 1° to 3° positive.

5. The method of claim 1, and wherein the selected static loft is so custom selected that, for use with relatively moderate speed greens having a mowed grass height of from approximately 0.156 inch to 0.281 inch, the resultant putter's curved strike face static loft is from approximately 2° to 4° positive.

6. The method of claim 1, and wherein the selected static loft is so custom selected that, for use with relatively slow speed greens having a mowed grass height of from approximately 0.172 inch to 0.281 inch, the resultant putter's curved strike face static loft is from 3° to 5° positive.

7. The method of claim 1, and, so as to accommodate the dynamic shaft angle delivered by a golfer having an extreme forward press putting stroke style, of increasing said static loft in the range of from approximately 3° to 5° positive loft for said static loft selected in step (b) above.

8. The method of claim 1, and, so as to accommodate the dynamic shart angle delivered by a

golfer having an extreme broken wrist putting stroke style, of reducing said static loft in the range of from approximately 1° to 3° positive loft from said static loft selected in step (b) above.

9. The method of claim 1, and determing the required X and Y displacements to find the center of curvature of the optimal roll radius calculated by step (c) above, wherein X and Y are determined using the equations of:

(1) "A" = sin (static loft) (0.5) (face height)

(2) "D" = $\frac{A}{\text{tan (static loft)}}$

(3) "C" = tan (static loft) (A)

(4) "B" = D + C

(5) "E" = sin (static loft) (face radius)

(6) "Y" dimension = B-E

(7) "X" dimension = cos (static loft) (face radius)

wherein A, B, C, D, and E are as set forth in FIGURE 18 of the DRAWINGS.

10. A plurality of vertically curved strike face putters, each said putter of the plurality, while having substantially the same face height and static loft, having a different roll radius for that given said putter's curved strike face, whereby a golfer on a given day can select which respective putter within the plurality best accommodates that golfer's putting stroke style and that given day's putting green

conditions.

11. An improved vertically curved strike face putter having an optimal roll radius to permit impacting the golf ball within a true roll impact zone falling within the range from approximately 0.018 inch to 0.073 inch below the ball's equator, the improvement comprising in combination:

a) a known face height (FH) for said curved strike face,

b) a known static loft selected for said curved strike face, and

c) said optimal roll radius formed on said curved strike face, based on said known face height (FH) and said known static loft, determined through the equations of:

(1) "A" = sin (static loft) (0.5) (face height)

(2) "C" = tan (static loft) (A)

(3) $h = \sqrt{A^2 + C^2}$

(4) $\text{Diameter} = \dfrac{(h^2 + (0.5 \text{ face height})^2)}{h}$

(5) $\text{Curved Radius} = \dfrac{\text{Diameter}}{2}$

12. The invention of claim 11, and wherein said known static loft falls within the range from approximately 1° to 5° positive loft.

13. The method of determining an optimal roll radius for a vertically curved strike face putter, comprising the steps of:

a) determining the face height of the selected

design of curved strike face putter;

b) selecting the static loft of the curved strike face; and

c) determining the required optimal roll radius, as a function of said determined face height and said selected static loft, whereby said optimal roll radius permits said curved strike face putter, regardless of a given golfer's putting stroke style and the golfer's own tolerance variations within that style, to consistently impact the golf ball within a true roll impact zone below the ball's equator so that the ball will achieve the earliest true roll.

14. The method of claim 13, and wherein said true roll impact zone is in the range from approximately 0.015 inch to 0.073 inch below the ball's equator.

15. The method of claim 13, and wherein said true roll impact zone for use on relatively fast speed putting greens is in the range from approximately 0.015 inch to 0.044 inch below the ball's equator.

16. The method of claim 13, and wherein said true roll impact zone for use on relatively average speed putting greens, is in the range from approximately 0.024 inch to 0.059 inch below the ball's equator.

17. The method of claim 13, and wherein

said two roll impact zone for use on relatively slow speed putting greens is in the range of from approximately 0.044 inch to 0.073 inch below the ball's equator.

18. An improved vertically-curved strike face putter able to consistently impact a golf ball within the ball's true roll impact zone below the ball's equator, regardless of a given golfer's putting stroke style, said putter's curved strike face formed of a selected face height and of a selected static loft, said curved strike face having an optimal roll radius resulting from said face height and static loft, said face height and said static loft selected from, and said resultant optimal roll radii, and the correlating X and Y displacement data for the center-of-curvature location for such resultant optimal roll radii, are established in, the following optimum roll radii charts:

Loft Angle	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007
C=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R=	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007
Diameter=	28.649	31.514	34.379	37.244	40.109	42.974	45.839	48.704	51.569	54.434	57.298	60.164	63.029	65.893	68.758	71.623	74.488	77.353	80.218	83.083	85.948
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	14.324	15.757	17.189	18.621	20.054	21.486	22.919	24.351	25.783	27.216	28.648	30.081	31.513	32.945	34.378	35.810	37.243	38.675	40.108	41.540	42.972
Roll Radius	**14.326**	**15.757**	**17.190**	**18.622**	**20.056**	**21.487**	**22.918**	**24.352**	**25.784**	**27.217**	**28.649**	**30.082**	**31.514**	**32.947**	**34.378**	**35.812**	**37.244**	**38.677**	**40.108**	**41.542**	**42.974**

Loft Angle	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.012	0.012	0.013	0.013
C=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R=	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.012	0.012	0.013	0.013
Diameter=	14.327	15.780	17.192	18.625	20.058	21.490	22.923	24.356	25.788	27.221	28.654	30.086	31.519	32.952	34.384	35.817	37.250	38.683	40.115	41.548	42.981
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	7.162	7.879	8.596	9.311	10.027	10.744	11.460	12.176	12.892	13.608	14.325	15.041	15.757	16.473	17.190	17.906	18.622	19.338	20.055	20.771	21.487
Roll Radius	**7.163**	**7.880**	**8.598**	**9.312**	**10.028**	**10.748**	**11.461**	**12.178**	**12.894**	**13.611**	**14.327**	**15.043**	**15.760**	**16.476**	**17.192**	**17.908**	**18.626**	**19.341**	**20.058**	**20.774**	**21.490**

Loft Angle	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.007	0.007	0.008	0.009	0.009	0.010	0.010	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.016	0.016	0.017	0.018	0.018	0.019	0.020
C=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
R=	0.007	0.007	0.008	0.009	0.009	0.010	0.010	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.016	0.016	0.017	0.018	0.018	0.019	0.020
Diameter=	9.554	10.509	11.464	12.420	13.375	14.330	15.286	16.241	17.197	18.152	19.107	20.063	21.018	21.973	22.929	23.884	24.840	25.795	26.750	27.706	28.661
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	4.775	5.253	5.730	6.208	6.685	7.163	7.640	8.118	8.596	9.073	9.550	10.028	10.505	10.983	11.460	11.938	12.416	12.893	13.371	13.848	14.326
Roll Radius	**4.777**	**5.255**	**5.732**	**6.210**	**6.688**	**7.166**	**7.643**	**8.121**	**8.598**	**9.076**	**9.554**	**10.031**	**10.508**	**10.987**	**11.464**	**11.942**	**12.420**	**12.897**	**13.376**	**13.853**	**14.330**

Loft Angle	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.009	0.010	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.024	0.025	0.026
C=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
h=	0.009	0.010	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.024	0.025	0.026
Diameter=	7.168	7.885	8.601	9.318	10.035	10.752	11.468	12.185	12.902	13.619	14.336	15.052	15.769	16.486	17.203	17.919	18.636	19.353	20.070	20.787	21.503
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	3.582	3.940	4.298	4.656	5.014	5.373	5.731	6.089	6.447	6.805	7.163	7.522	7.880	8.238	8.596	8.954	9.312	9.671	10.029	10.387	10.745
Roll Radius	**3.584**	**3.942**	**4.301**	**4.660**	**5.017**	**5.376**	**5.734**	**6.093**	**6.451**	**6.809**	**7.168**	**7.526**	**7.885**	**8.243**	**8.601**	**8.960**	**9.318**	**9.677**	**10.035**	**10.393**	**10.752**

Loft Angle	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.019	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.031	0.032	0.033
C=	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
h=	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.019	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.031	0.032	0.033
Diameter=	5.737	6.311	6.884	7.458	8.032	8.605	9.179	9.753	10.326	10.900	11.474	12.047	12.621	13.195	13.768	14.342	14.916	15.490	16.063	16.637	17.211
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.549	0.574	0.599	0.624	0.649	0.674	0.699	0.724	0.749
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.526	0.551	0.576	0.601	0.626	0.651	0.676	0.701	0.726	0.751
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	2.866	3.152	3.439	3.725	4.012	4.299	4.585	4.872	5.158	5.445	5.731	6.018	6.305	6.591	6.878	7.164	7.451	7.737	8.024	8.311	8.597
Roll Radius	**2.868**	**3.155**	**3.442**	**3.729**	**4.016**	**4.303**	**4.589**	**4.876**	**5.163**	**5.450**	**5.737**	**6.024**	**6.311**	**6.597**	**6.884**	**7.171**	**7.458**	**7.745**	**8.032**	**8.318**	**8.605**

Loft Angle	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.013	0.014	0.016	0.017	0.018	0.020	0.021	0.022	0.024	0.025	0.026	0.027	0.029	0.030	0.031	0.033	0.034	0.035	0.037	0.038	0.039
C=	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
h=	0.013	0.014	0.016	0.017	0.018	0.020	0.021	0.022	0.024	0.025	0.026	0.028	0.029	0.030	0.031	0.033	0.034	0.035	0.037	0.038	0.039
Diameter=	4.783	5.262	5.740	6.218	6.697	7.175	7.653	8.132	8.610	9.088	9.567	10.045	10.523	11.002	11.480	11.958	12.437	12.915	13.393	13.872	14.350
D=	0.250	0.275	0.300	0.325	0.350	0.374	0.399	0.424	0.449	0.474	0.499	0.524	0.549	0.574	0.599	0.624	0.649	0.674	0.699	0.724	0.749
B=	0.250	0.275	0.300	0.325	0.350	0.376	0.401	0.426	0.451	0.476	0.501	0.526	0.551	0.576	0.601	0.626	0.651	0.676	0.701	0.726	0.751
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.376
"Y"=	0.125	0.138	0.150	0.183	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.376
"X"=	2.388	2.627	2.866	3.105	3.344	3.583	3.821	4.060	4.299	4.538	4.777	5.016	5.255	5.493	5.732	5.971	6.210	6.449	6.688	6.926	7.165
Roll Radius	**2.392**	**2.631**	**2.870**	**3.109**	**3.348**	**3.588**	**3.827**	**4.066**	**4.305**	**4.544**	**4.783**	**5.023**	**5.262**	**5.501**	**5.740**	**5.979**	**6.218**	**6.458**	**6.697**	**6.936**	**7.175**

Loft Angle	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.015	0.017	0.018	0.020	0.021	0.023	0.024	0.026	0.027	0.029	0.031	0.032	0.034	0.035	0.037	0.038	0.040	0.041	0.043	0.044	0.046
C=	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003
h=	0.015	0.017	0.018	0.020	0.021	0.023	0.024	0.026	0.028	0.029	0.031	0.032	0.034	0.035	0.037	0.038	0.040	0.041	0.043	0.044	0.046
Diameter=	4.103	4.513	4.923	5.334	5.744	6.154	6.564	6.975	7.385	7.795	8.206	8.616	9.026	9.436	9.847	10.257	10.667	11.077	11.488	11.898	12.308
D=	0.250	0.274	0.299	0.324	0.349	0.374	0.399	0.424	0.449	0.474	0.499	0.524	0.549	0.574	0.599	0.624	0.649	0.674	0.699	0.724	0.749
B=	0.250	0.276	0.301	0.326	0.351	0.376	0.401	0.426	0.451	0.476	0.501	0.526	0.551	0.576	0.601	0.626	0.651	0.676	0.701	0.726	0.751
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.276	0.288	0.301	0.313	0.326	0.338	0.351	0.363	0.376
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.276	0.288	0.301	0.313	0.326	0.338	0.351	0.363	0.376
"X"=	2.048	2.252	2.457	2.662	2.867	3.071	3.276	3.481	3.686	3.890	4.095	4.300	4.505	4.709	4.914	5.119	5.324	5.528	5.733	5.938	6.143
Roll Radius	**2.051**	**2.257**	**2.462**	**2.667**	**2.872**	**3.077**	**3.282**	**3.487**	**3.692**	**3.898**	**4.103**	**4.308**	**4.513**	**4.718**	**4.923**	**5.128**	**5.334**	**5.539**	**5.744**	**5.949**	**6.154**

Loft Angle	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.017	0.019	0.021	0.023	0.024	0.026	0.028	0.030	0.031	0.033	0.035	0.037	0.038	0.040	0.042	0.044	0.045	0.047	0.049	0.051	0.052
C=	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004
h=	0.017	0.019	0.021	0.023	0.024	0.026	0.028	0.030	0.031	0.033	0.035	0.037	0.038	0.040	0.042	0.044	0.045	0.047	0.049	0.051	0.052
Diameter=	3.593	3.952	4.311	4.670	5.030	5.389	5.748	6.108	6.467	6.826	7.185	7.545	7.904	8.263	8.622	8.982	9.341	9.700	10.059	10.419	10.778
D=	0.249	0.274	0.299	0.324	0.349	0.374	0.399	0.424	0.449	0.474	0.499	0.524	0.549	0.574	0.599	0.623	0.648	0.673	0.698	0.723	0.748
B=	0.251	0.276	0.301	0.326	0.351	0.376	0.401	0.426	0.451	0.476	0.501	0.526	0.551	0.576	0.601	0.627	0.652	0.677	0.702	0.727	0.752
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313	0.326	0.338	0.351	0.363	0.376
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313	0.326	0.338	0.351	0.363	0.376
"X"=	1.792	1.971	2.150	2.330	2.509	2.688	2.867	3.046	3.226	3.405	3.584	3.763	3.942	4.121	4.301	4.480	4.659	4.838	5.017	5.197	5.376
Roll Radius	**1.796**	**1.976**	**2.156**	**2.336**	**2.516**	**2.694**	**2.874**	**3.054**	**3.233**	**3.413**	**3.593**	**3.772**	**3.952**	**4.132**	**4.311**	**4.491**	**4.670**	**4.850**	**5.030**	**5.209**	**5.389**

Loft Angle	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.020	0.022	0.024	0.025	0.027	0.029	0.031	0.033	0.035	0.037	0.039	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.055	0.057	0.059
C=	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005
h=	0.020	0.022	0.024	0.026	0.028	0.030	0.031	0.033	0.035	0.037	0.039	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.055	0.057	0.059
Diameter=	3.196	3.516	3.835	4.155	4.475	4.794	5.114	5.434	5.753	6.073	6.392	6.712	7.032	7.351	7.671	7.991	8.310	8.630	8.949	9.269	9.589
D=	0.249	0.274	0.299	0.324	0.349	0.374	0.399	0.424	0.449	0.474	0.498	0.523	0.548	0.573	0.598	0.623	0.648	0.673	0.698	0.723	0.748
B=	0.251	0.276	0.301	0.326	0.351	0.376	0.401	0.426	0.451	0.476	0.502	0.527	0.552	0.577	0.602	0.627	0.652	0.677	0.702	0.727	0.752
E=	0.125	0.138	0.150	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313	0.326	0.339	0.351	0.364	0.376
"Y"=	0.125	0.138	0.150	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313	0.326	0.339	0.351	0.364	0.376
"X"=	1.593	1.753	1.912	2.071	2.230	2.390	2.549	2.708	2.868	3.027	3.186	3.346	3.505	3.664	3.824	3.983	4.142	4.302	4.461	4.620	4.780
Roll Radius	**1.598**	**1.758**	**1.918**	**2.078**	**2.237**	**2.397**	**2.557**	**2.717**	**2.877**	**3.036**	**3.196**	**3.356**	**3.516**	**3.676**	**3.836**	**3.996**	**4.156**	**4.316**	**4.476**	**4.636**	**4.794**

Loft Angle	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.022	0.024	0.026	0.028	0.031	0.033	0.035	0.037	0.039	0.041	0.044	0.046	0.048	0.050	0.052	0.054	0.057	0.059	0.061	0.063	0.065
C=	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006
h=	0.022	0.024	0.026	0.028	0.031	0.033	0.035	0.037	0.039	0.042	0.044	0.046	0.048	0.050	0.052	0.056	0.057	0.059	0.061	0.063	0.066
Diameter=	2.879	3.167	3.455	3.743	4.031	4.319	4.607	4.895	5.183	5.471	5.759	6.047	6.335	6.623	6.911	7.198	7.486	7.774	8.062	8.350	8.638
D=	0.249	0.274	0.299	0.324	0.349	0.374	0.398	0.423	0.448	0.473	0.498	0.523	0.548	0.573	0.598	0.623	0.648	0.672	0.697	0.722	0.747
B=	0.251	0.276	0.301	0.326	0.351	0.376	0.402	0.427	0.452	0.477	0.502	0.527	0.552	0.577	0.602	0.627	0.652	0.678	0.703	0.728	0.753
E=	0.125	0.138	0.151	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.264	0.276	0.289	0.301	0.314	0.326	0.339	0.351	0.364	0.376
"Y"=	0.125	0.138	0.151	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.264	0.276	0.289	0.301	0.314	0.326	0.339	0.351	0.364	0.376
"X"=	1.434	1.578	1.721	1.864	2.008	2.151	2.295	2.438	2.582	2.725	2.868	3.012	3.155	3.299	3.442	3.586	3.729	3.872	4.016	4.159	4.303
Roll Radius	**1.440**	**1.584**	**1.728**	**1.872**	**2.016**	**2.160**	**2.304**	**2.447**	**2.591**	**2.735**	**2.879**	**3.023**	**3.167**	**3.311**	**3.455**	**3.599**	**3.743**	**3.887**	**4.031**	**4.175**	**4.319**

Loft Angle	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.024	0.026	0.029	0.031	0.034	0.036	0.038	0.041	0.043	0.046	0.048	0.050	0.053	0.055	0.058	0.060	0.062	0.065	0.067	0.069	0.072
C=	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007
h=	0.024	0.026	0.029	0.031	0.034	0.036	0.038	0.041	0.043	0.046	0.048	0.051	0.053	0.055	0.058	0.060	0.063	0.065	0.067	0.070	0.072
Diameter=	2.620	2.882	3.145	3.407	3.669	3.931	4.193	4.455	4.717	4.979	5.241	5.503	5.765	6.027	6.289	6.551	6.813	7.075	7.337	7.599	7.861
D=	0.249	0.274	0.299	0.324	0.348	0.373	0.398	0.423	0.448	0.473	0.498	0.523	0.547	0.572	0.597	0.622	0.647	0.672	0.697	0.722	0.747
B=	0.251	0.276	0.301	0.327	0.352	0.377	0.402	0.427	0.452	0.477	0.502	0.527	0.553	0.578	0.603	0.628	0.653	0.678	0.703	0.728	0.753
E=	0.126	0.138	0.151	0.163	0.176	0.188	0.201	0.213	0.226	0.239	0.251	0.264	0.276	0.289	0.301	0.314	0.327	0.339	0.352	0.364	0.377
"Y"=	0.126	0.138	0.151	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.264	0.276	0.289	0.301	0.314	0.327	0.339	0.352	0.364	0.377
"X"=	1.304	1.435	1.565	1.695	1.826	1.956	2.087	2.217	2.348	2.478	2.608	2.739	2.869	3.000	3.130	3.260	3.391	3.521	3.652	3.782	3.913
Roll Radius	**1.310**	**1.441**	**1.572**	**1.703**	**1.834**	**1.965**	**2.096**	**2.227**	**2.358**	**2.489**	**2.620**	**2.751**	**2.882**	**3.013**	**3.145**	**3.276**	**3.407**	**3.538**	**3.669**	**3.800**	**3.931**

Loft Angle	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.026	0.029	0.031	0.034	0.037	0.039	0.042	0.044	0.047	0.050	0.052	0.055	0.057	0.060	0.063	0.065	0.068	0.071	0.073	0.076	0.078
C=	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008
h=	0.028	0.029	0.032	0.034	0.037	0.039	0.042	0.045	0.047	0.050	0.053	0.055	0.058	0.060	0.063	0.066	0.068	0.071	0.074	0.076	0.079
Diameter=	2.405	2.645	2.888	3.126	3.367	3.607	3.848	4.088	4.329	4.569	4.810	5.050	5.291	5.531	5.772	6.012	6.253	6.493	6.734	6.974	7.215
D=	0.249	0.273	0.298	0.323	0.348	0.373	0.398	0.423	0.448	0.472	0.497	0.522	0.547	0.572	0.597	0.622	0.646	0.671	0.696	0.721	0.746
B=	0.251	0.277	0.302	0.327	0.352	0.377	0.402	0.427	0.452	0.478	0.503	0.528	0.553	0.578	0.603	0.628	0.654	0.679	0.704	0.729	0.754
E=	0.126	0.138	0.151	0.163	0.176	0.189	0.201	0.214	0.226	0.239	0.251	0.264	0.277	0.289	0.302	0.314	0.327	0.339	0.352	0.364	0.377
"Y"=	0.126	0.138	0.151	0.163	0.176	0.189	0.201	0.214	0.226	0.239	0.251	0.264	0.277	0.289	0.302	0.314	0.327	0.339	0.352	0.364	0.377
"X"=	1.196	1.315	1.435	1.555	1.674	1.794	1.913	2.033	2.153	2.272	2.392	2.511	2.631	2.750	2.870	2.990	3.109	3.229	3.348	3.468	3.588
Roll Radius	1.202	1.323	1.443	1.563	1.683	1.804	1.924	2.044	2.164	2.285	2.405	2.526	2.646	2.766	2.886	3.006	3.126	3.247	3.367	3.487	3.607

Loft Angle	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.028	0.031	0.034	0.037	0.040	0.042	0.045	0.048	0.051	0.054	0.057	0.059	0.062	0.065	0.068	0.071	0.074	0.076	0.079	0.082	0.085
C=	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.010
h=	0.028	0.031	0.034	0.037	0.040	0.043	0.046	0.048	0.051	0.054	0.057	0.060	0.063	0.066	0.068	0.071	0.074	0.077	0.080	0.083	0.085
Diameter=	2.223	2.445	2.667	2.890	3.112	3.334	3.556	3.779	4.001	4.223	4.445	4.668	4.890	5.112	5.334	5.557	5.779	6.001	6.224	6.446	6.668
D=	0.248	0.273	0.298	0.323	0.348	0.373	0.397	0.422	0.447	0.472	0.497	0.522	0.546	0.571	0.596	0.621	0.646	0.671	0.696	0.720	0.745
B=	0.252	0.277	0.302	0.327	0.352	0.377	0.403	0.428	0.453	0.478	0.503	0.528	0.554	0.579	0.604	0.629	0.654	0.679	0.705	0.730	0.755
E=	0.126	0.138	0.151	0.164	0.176	0.189	0.201	0.214	0.226	0.239	0.252	0.264	0.277	0.289	0.302	0.315	0.327	0.340	0.352	0.365	0.377
"Y"=	0.126	0.138	0.151	0.164	0.176	0.189	0.201	0.214	0.226	0.239	0.252	0.264	0.277	0.289	0.302	0.315	0.327	0.340	0.352	0.365	0.377
"X"=	1.104	1.215	1.325	1.436	1.546	1.656	1.767	1.877	1.988	2.098	2.208	2.319	2.429	2.540	2.650	2.761	2.871	2.981	3.092	3.202	3.313
Roll Radius	1.111	1.222	1.334	1.445	1.556	1.667	1.778	1.889	2.000	2.112	2.223	2.334	2.445	2.556	2.667	2.778	2.890	3.001	3.112	3.223	3.334

Loft Angle	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.030	0.034	0.037	0.040	0.043	0.046	0.049	0.052	0.055	0.058	0.061	0.064	0.067	0.070	0.073	0.076	0.079	0.082	0.085	0.088	0.091
C=	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.011	0.011
h=	0.031	0.034	0.037	0.040	0.043	0.046	0.049	0.052	0.055	0.058	0.061	0.064	0.068	0.071	0.074	0.077	0.080	0.083	0.086	0.089	0.092
Diameter=	2.067	2.273	2.480	2.687	2.893	3.100	3.307	3.514	3.720	3.927	4.134	4.340	4.547	4.754	4.960	5.167	5.374	5.580	5.787	5.994	6.200
D=	0.248	0.273	0.298	0.323	0.347	0.372	0.397	0.422	0.447	0.471	0.496	0.521	0.546	0.571	0.596	0.620	0.645	0.670	0.695	0.720	0.744
B=	0.252	0.277	0.302	0.327	0.353	0.378	0.403	0.428	0.453	0.478	0.504	0.529	0.554	0.579	0.605	0.630	0.655	0.680	0.705	0.730	0.756
E=	0.126	0.139	0.151	0.164	0.176	0.189	0.202	0.214	0.227	0.239	0.252	0.264	0.277	0.290	0.302	0.315	0.327	0.340	0.353	0.365	0.378
"Y"=	0.126	0.139	0.151	0.164	0.176	0.189	0.202	0.214	0.227	0.239	0.252	0.264	0.277	0.290	0.302	0.315	0.327	0.340	0.353	0.365	0.378
"X"=	1.026	1.128	1.231	1.333	1.436	1.539	1.641	1.744	1.846	1.949	2.051	2.154	2.257	2.359	2.462	2.564	2.667	2.769	2.872	2.974	3.077
Roll Radius	1.033	1.137	1.240	1.343	1.447	1.550	1.653	1.757	1.860	1.963	2.067	2.170	2.273	2.377	2.480	2.583	2.687	2.790	2.893	2.997	3.100

Loft Angle	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.033	0.036	0.039	0.042	0.046	0.049	0.052	0.055	0.059	0.062	0.065	0.069	0.072	0.075	0.078	0.082	0.085	0.088	0.091	0.095	0.098
C=	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.010	0.010	0.011	0.011	0.012	0.012	0.012	0.013
h=	0.033	0.036	0.039	0.043	0.046	0.049	0.053	0.056	0.059	0.063	0.066	0.069	0.072	0.076	0.079	0.082	0.086	0.089	0.092	0.095	0.099
Diameter=	1.932	2.125	2.318	2.511	2.705	2.898	3.091	3.284	3.477	3.671	3.864	4.057	4.250	4.443	4.636	4.830	5.023	5.216	5.409	5.602	5.796
D=	0.248	0.273	0.297	0.322	0.347	0.372	0.397	0.421	0.446	0.471	0.496	0.521	0.545	0.570	0.595	0.620	0.644	0.669	0.694	0.719	0.744
B=	0.252	0.277	0.303	0.328	0.353	0.378	0.403	0.429	0.454	0.479	0.504	0.530	0.555	0.580	0.605	0.630	0.656	0.681	0.706	0.731	0.756
E=	0.126	0.139	0.151	0.164	0.177	0.189	0.202	0.214	0.227	0.240	0.252	0.265	0.277	0.290	0.303	0.315	0.328	0.340	0.353	0.366	0.378
"Y"=	0.126	0.139	0.151	0.164	0.177	0.189	0.202	0.214	0.227	0.240	0.252	0.265	0.277	0.290	0.303	0.315	0.328	0.340	0.353	0.366	0.378
"X"=	0.958	1.053	1.149	1.245	1.341	1.436	1.532	1.628	1.724	1.820	1.915	2.011	2.107	2.203	2.298	2.394	2.490	2.586	2.681	2.777	2.873
Roll Radius	0.968	1.063	1.159	1.256	1.352	1.449	1.545	1.642	1.739	1.836	1.932	2.028	2.126	2.222	2.318	2.415	2.511	2.608	2.706	2.801	2.898

Loft Angle	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.035	0.038	0.042	0.045	0.049	0.052	0.056	0.059	0.063	0.066	0.070	0.073	0.077	0.080	0.084	0.087	0.090	0.094	0.097	0.101	0.104
C=	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.015
h=	0.035	0.039	0.042	0.046	0.049	0.053	0.056	0.060	0.063	0.067	0.070	0.074	0.077	0.081	0.084	0.088	0.091	0.095	0.098	0.102	0.105
Diameter=	1.814	1.995	2.177	2.358	2.540	2.721	2.902	3.084	3.265	3.447	3.628	3.809	3.991	4.172	4.354	4.535	4.716	4.898	5.079	5.261	5.442
D=	0.248	0.272	0.297	0.322	0.347	0.371	0.396	0.421	0.446	0.470	0.495	0.520	0.545	0.569	0.594	0.619	0.644	0.668	0.693	0.718	0.743
B=	0.252	0.278	0.303	0.328	0.353	0.379	0.404	0.429	0.454	0.480	0.505	0.530	0.555	0.581	0.606	0.631	0.656	0.682	0.707	0.732	0.757
E=	0.126	0.139	0.151	0.164	0.177	0.189	0.202	0.215	0.227	0.240	0.252	0.265	0.278	0.290	0.303	0.316	0.328	0.341	0.353	0.366	0.379
"Y"=	0.126	0.139	0.151	0.164	0.177	0.189	0.202	0.215	0.227	0.240	0.252	0.265	0.278	0.290	0.303	0.316	0.328	0.341	0.353	0.366	0.379
"X"=	0.898	0.988	1.078	1.168	1.257	1.347	1.437	1.527	1.617	1.707	1.796	1.886	1.976	2.066	2.156	2.245	2.335	2.425	2.515	2.605	2.694
Roll Radius	**0.907**	**0.998**	**1.088**	**1.179**	**1.270**	**1.360**	**1.451**	**1.542**	**1.633**	**1.723**	**1.814**	**1.905**	**1.996**	**2.086**	**2.177**	**2.267**	**2.358**	**2.449**	**2.540**	**2.630**	**2.721**

Loft Angle	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.037	0.041	0.044	0.048	0.052	0.055	0.059	0.063	0.067	0.070	0.074	0.078	0.081	0.085	0.089	0.092	0.096	0.100	0.103	0.107	0.111
C=	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.015	0.015	0.016	0.017
h=	0.037	0.041	0.045	0.049	0.052	0.056	0.060	0.064	0.067	0.071	0.075	0.078	0.082	0.086	0.090	0.093	0.097	0.101	0.105	0.108	0.112
Diameter=	1.710	1.881	2.052	2.223	2.394	2.565	2.736	2.907	3.078	3.249	3.420	3.591	3.762	3.933	4.104	4.275	4.446	4.617	4.788	4.959	5.130
D=	0.247	0.272	0.297	0.321	0.346	0.371	0.396	0.420	0.445	0.470	0.495	0.519	0.544	0.569	0.593	0.618	0.643	0.668	0.692	0.717	0.742
B=	0.253	0.278	0.303	0.329	0.354	0.379	0.404	0.430	0.455	0.480	0.506	0.531	0.556	0.581	0.607	0.632	0.657	0.682	0.708	0.733	0.758
E=	0.126	0.139	0.152	0.164	0.177	0.190	0.202	0.216	0.227	0.240	0.253	0.265	0.278	0.291	0.303	0.316	0.329	0.341	0.354	0.387	0.378
"Y"=	0.126	0.139	0.152	0.164	0.177	0.190	0.202	0.215	0.227	0.240	0.253	0.265	0.278	0.291	0.303	0.316	0.329	0.341	0.354	0.367	0.378
"X"=	0.846	0.930	1.015	1.099	1.184	1.269	1.353	1.438	1.522	1.607	1.691	1.776	1.861	1.945	2.030	2.114	2.199	2.283	2.368	2.452	2.537
Roll Radius	**0.855**	**0.941**	**1.026**	**1.112**	**1.197**	**1.283**	**1.368**	**1.454**	**1.539**	**1.625**	**1.710**	**1.796**	**1.881**	**1.967**	**2.052**	**2.138**	**2.223**	**2.309**	**2.394**	**2.480**	**2.565**

as comprising FIGURES 20A through 20E, inclusive, of the Drawings.

19. The improved curved strike face putter of claim 18, wherein said true roll impact zone falls within the range of approximately .015 inch to 0.073 inch below the ball's equator.

20. An improved vertically-curved face golf putter formed with a curved strike for having an optimal roll radius so as to permit consistentaly impacting a golf ball, regardless of a specific golfer's putting stroke style, within the true roll impact zone below the golf ball's equator, said curved strike face having a given face height and a selected static loft, said face height and static loft, and the resultant said optimal roll radius thereof, are as set forth in the charts comprising FIGURES 20A through 20E, inclusive, of the Drawings.

21. The improved vertically-curved face golf putter of claim 20, and wherein the required X- and Y- displacements for locating the center of curvature for the resultant said optimal roll radius are as given in the charts comprising FIGURES 20A through 20E, inclusive, of the Drawings.

22. The invention of claim 20, and wherein said putter includes two different roll radii, a first roll radius being the primary strike roll radius for impacting the golf ball in the true roll impact zone,

said first roll radius vertically extending within the range of approximately 45% to 85% of the lower height of said curved strike face; a second roll radius being provided to create the visual appearance of a curved strike face, said second roll radius vertically extending within the range of approximately 15% to 40% of the upper height of said curved strike face; and the radius of said second roll radius is less than the radius of said first roll radius.

23. The invention of claim 22, and a third roll radius for said curved strike face and formed at the lowermost edge portion of said curved strike face.

24. The invention of claim 22, wherein the value for said first roll radius is selected from the charts of FIGURES 20A to 20E, inclusive, of the Drawings.

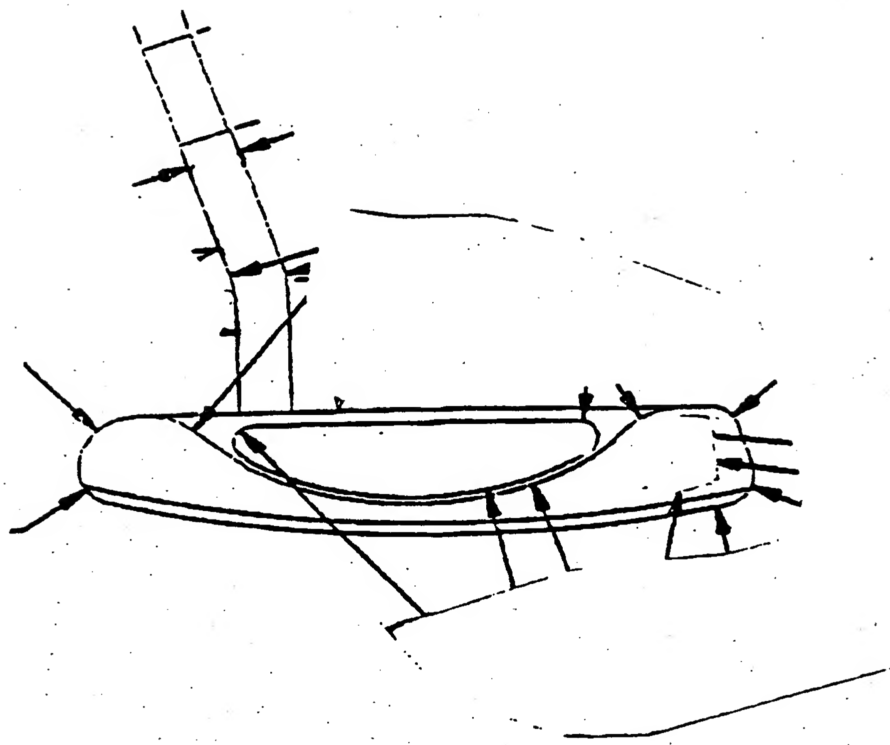
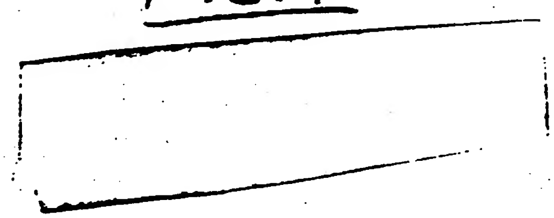


FIG. 1



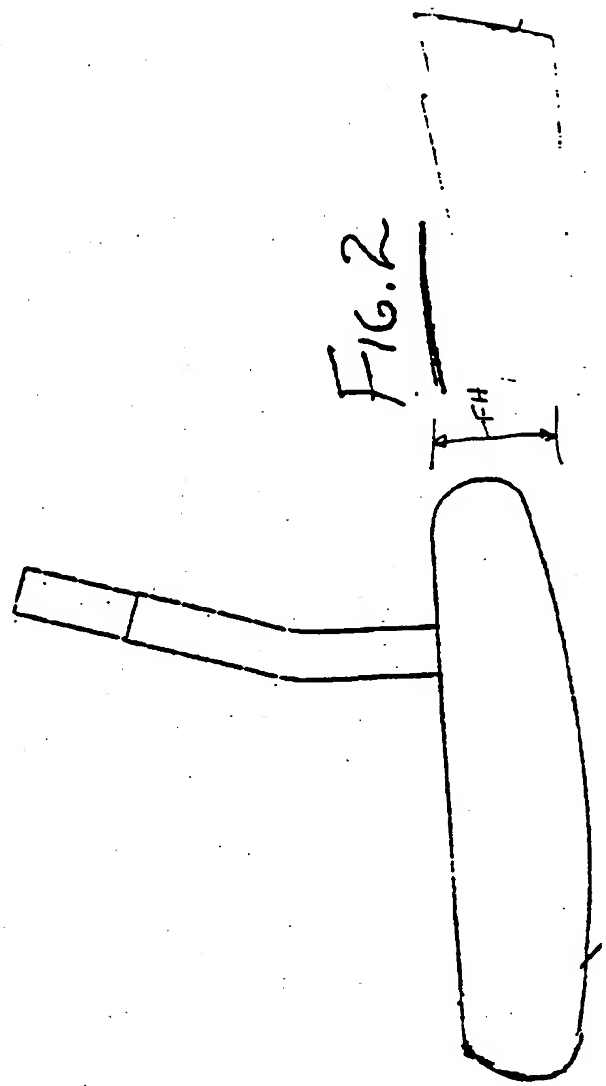


FIG. 2

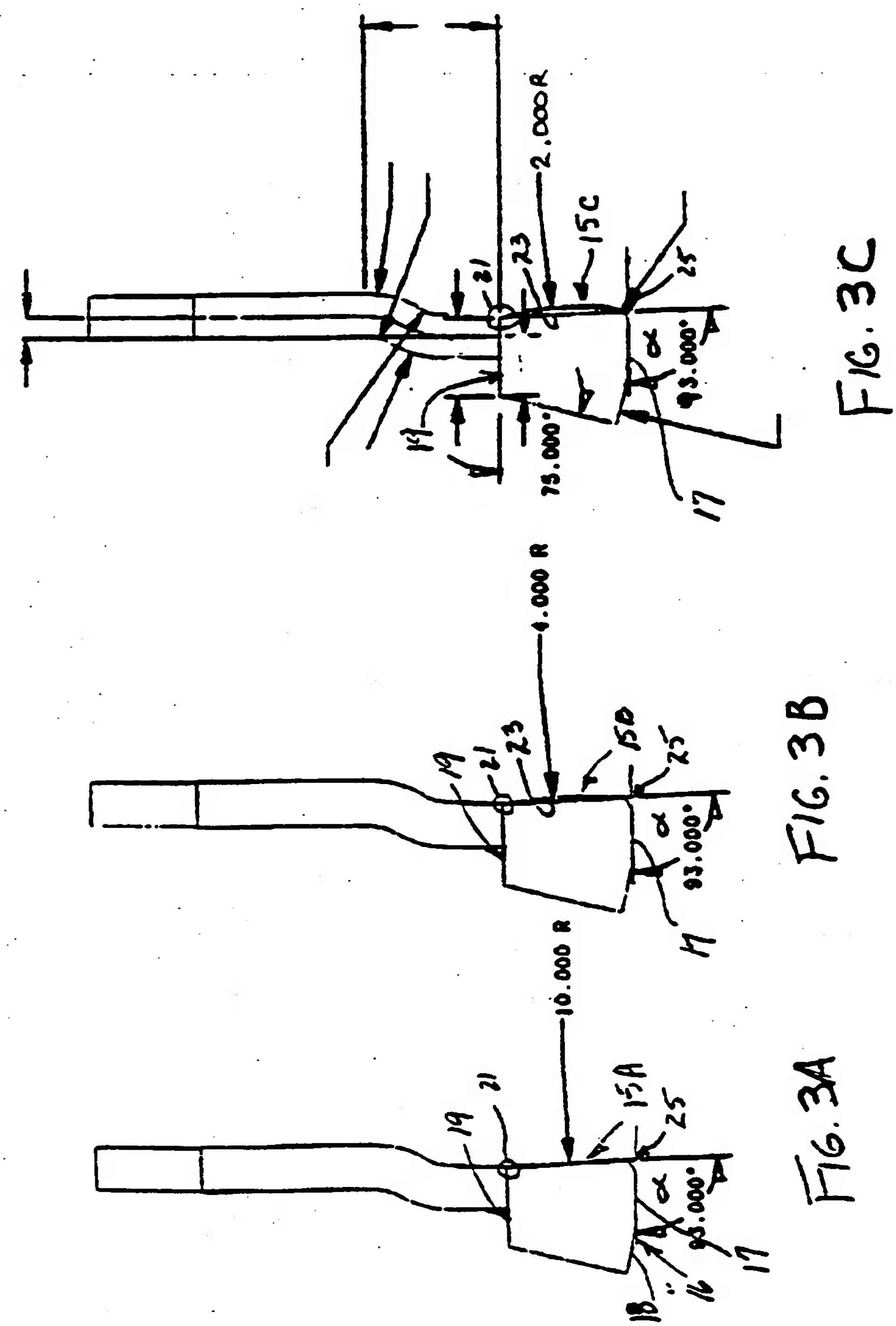


FIG. 3A

FIG. 3B

FIG. 3C

FIG. 4

General Equations and Definitions For Determining True Roll:

Vc=	Velocity at Center of the Golf Ball
Vs =	Velocity at Surface of the Golf Ball
d=	Distance Between Centers at 1/30th sec
W=	angular velocity of the Golf Ball
rad=	radius of Golf Ball = 0.840"
ang=	Angle of Rotation
time=	0.033333secs (1/30th sec.)

1 ***Vs=rad*w*** (in/sec)

w=(ang*pi/180)/time (x/sec)

2 ***Vc=d/time*** (in/sec)

3 ***No slip Angle = (360*d)/(5.27787)***

5.27787" = Golf Ball Circumference

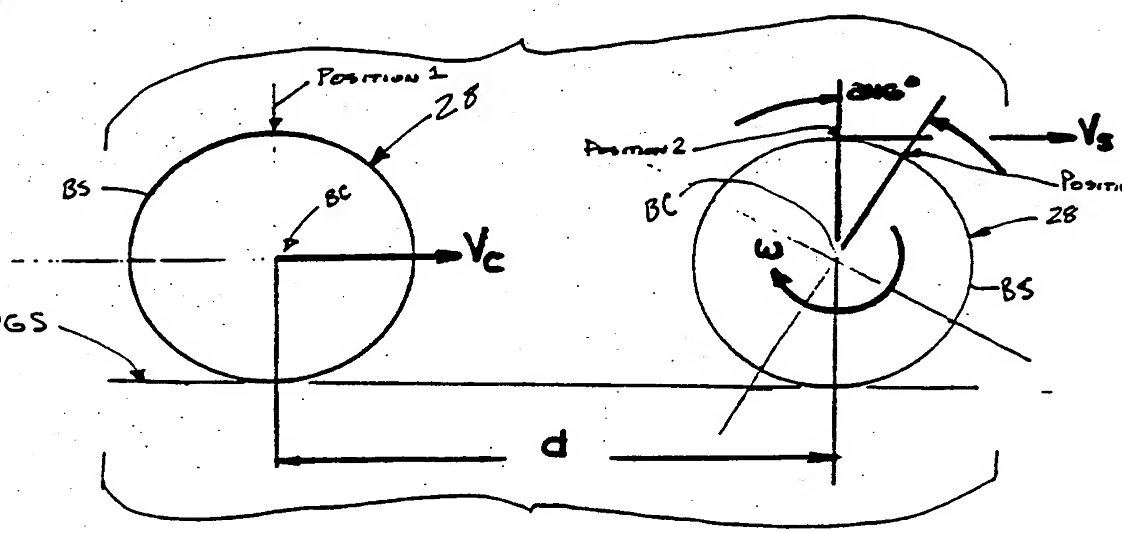


FIG. 5

TRUE ROLL TEST RESULTS :

Measured Putter Loft 3 degrees
Measured

Ball Position (in 3rds of Second)	Measured x displacement	Measured y displacement	Measured Angle of Rotation	"No Slip" Angle	Relative Angle of Rotation	Relative x displacement	Calculated Velocity Surface	Calculated Velocity Center
1	0.000	0.840	0.0	0.0	0.0	0.000	0.0	0.0
2	1.250	0.900	15.5	85.3	15.5	1.250	6.8	37.5
3	2.625	0.950	24.5	179.0	9.0	1.375	4.0	41.3
4	3.938	0.850	32.0	268.6	7.5	1.313	3.3	39.4
5	5.125	0.840	55.0	349.6	23.0	1.188	10.1	35.6
6	6.188	0.950	88.0	422.0	33.0	1.063	14.5	31.9
7	7.375	0.990	126.0	503.0	38.0	1.188	16.7	35.6
8	8.625	1.110	164.0	588.3	28.0	1.250	12.3	37.5
9	9.938	0.940	199.0	677.8	45.0	1.313	19.8	39.4
10	11.125	0.900	249.0	758.8	50.0	1.188	22.0	35.6
11	12.000	0.875	302.0°	816.5	53.0	0.875	23.3	26.3
12	12.750	0.840	360.0	869.7°	58.0	0.750	25.5	22.5

FIG.6

NOTE: "Relative Angle of Rotation" reflects incremental difference in Measured Angle of Rotation between ball positions, i.e. over time increments. "No Slip Angle" reflects theoretical calculation of Angle of Rotation based on each Measured X Displacement. Thus No Slip Angle = (X Displacement Value times 360)/5.27 (or the measured circumference of golf ball tested).

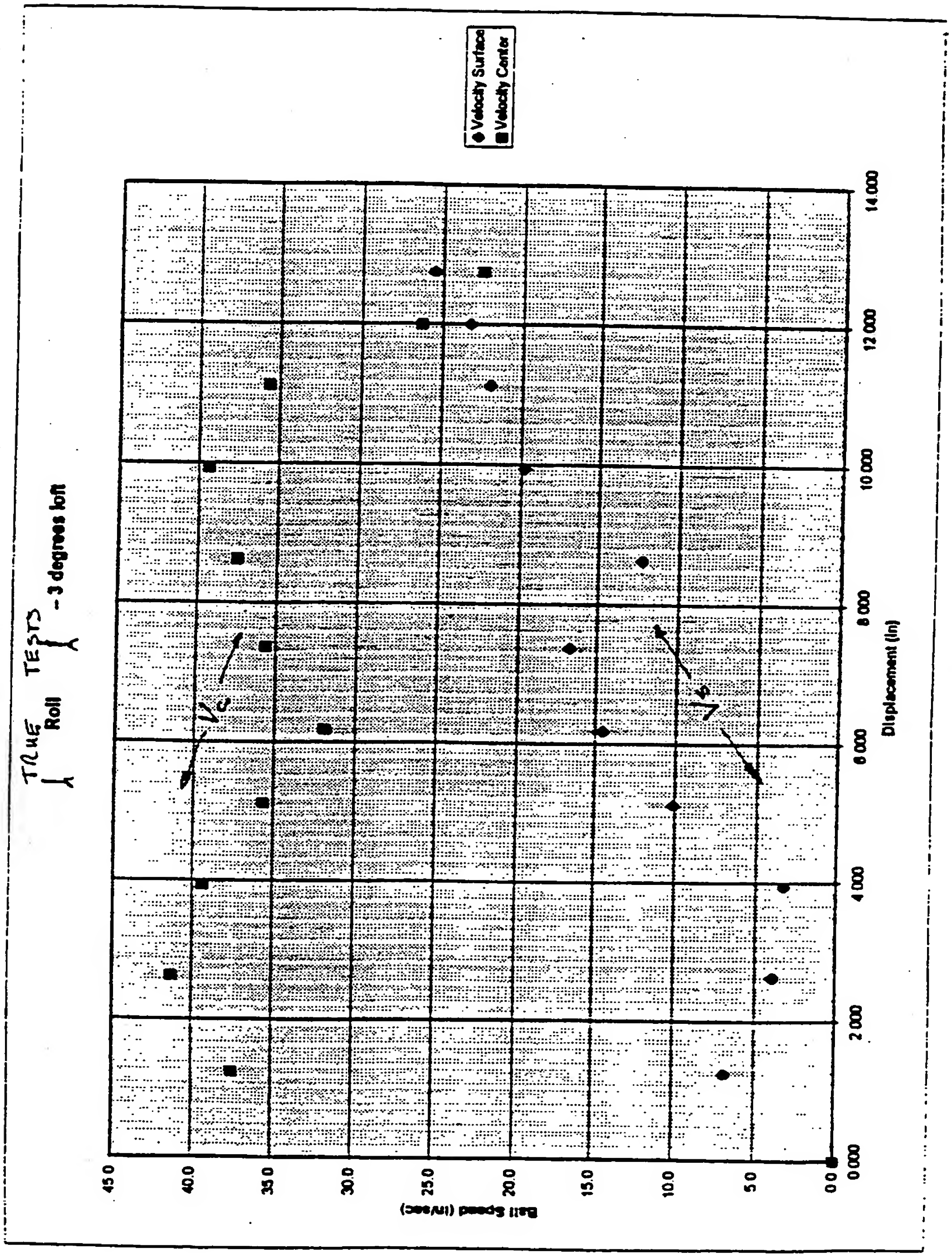

TRUE Roll TESTS
- 3 degrees loft
Velocity Surface
Velocity Center
Vc
Vs
Ball Speed (in/sec)
Displacement (in)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
0.000
2.000
4.000
6.000
8.000
10.000
12.000
14.000

FIG. 7

FIG. 8

Calculated Best Line Fit Data

Ball Position	Absolute x displacement	Velocity Surface	Velocity Center
1	0.000	0.5	42.029
2	1.250	2.9	40.797
3	2.625	5.5	39.441
4	3.938	7.9	38.146
5	5.125	10.2	36.975
6	6.188	12.2	35.927
7	7.375	14.4	34.756
8	8.625	16.8	33.524
9	9.938	19.3	32.229
10	11.125	21.5	31.058
11	12.000	23.1	30.195
12	12.750	24.5	29.455

Velocity of Surface = 1.8849*(x displacement) + 0.5253
Velocity of Center = -0.98619*(x displacement) + 42.0294

When *Velocity (surace)* = *Velocity (center)*, HAVE TRUE. ROLL

x displacement	14.456 in
Velocity Surface	27.8 in/sec
Velocity Center	27.8 in/sec
Putt Distance	120 in (or 10 ft.)
% of Putt in Roll	87.95%
% of Putt in Skid	12.05%

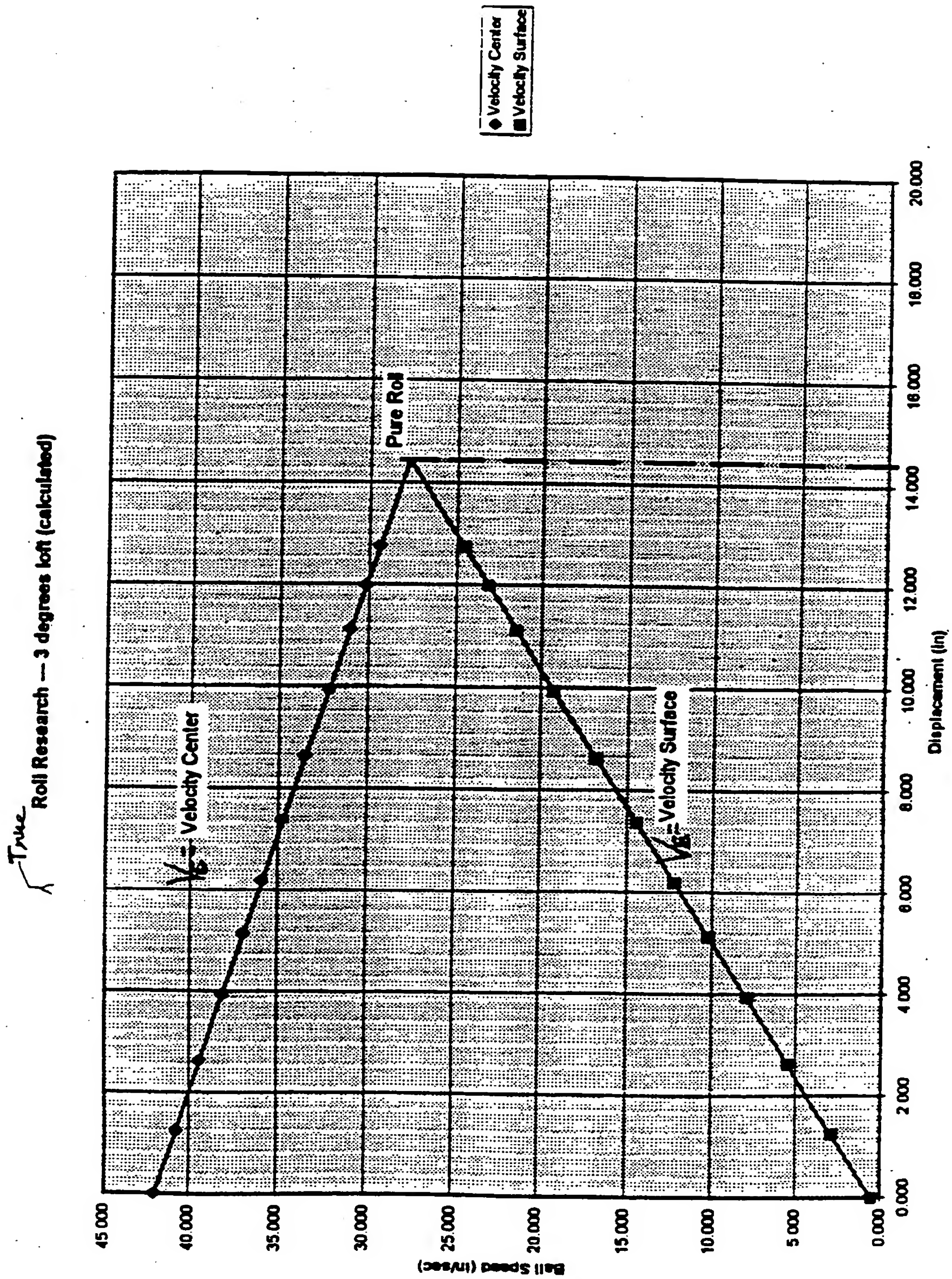


FIG. 9

BEST AVAILABLE COPY

Loft	λ^{TRUE} Roll
0	17.5
2	15.75
4	16.25
6	18.5
8	20
10	21

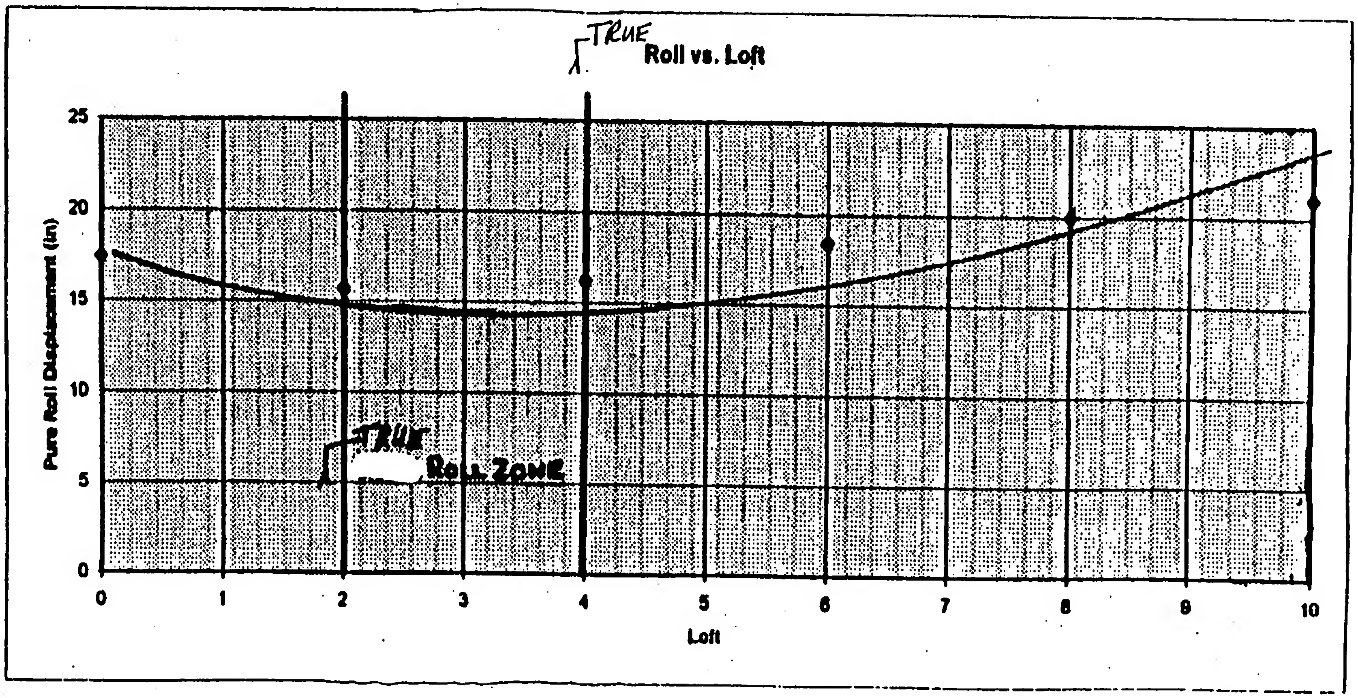


FIG. 10

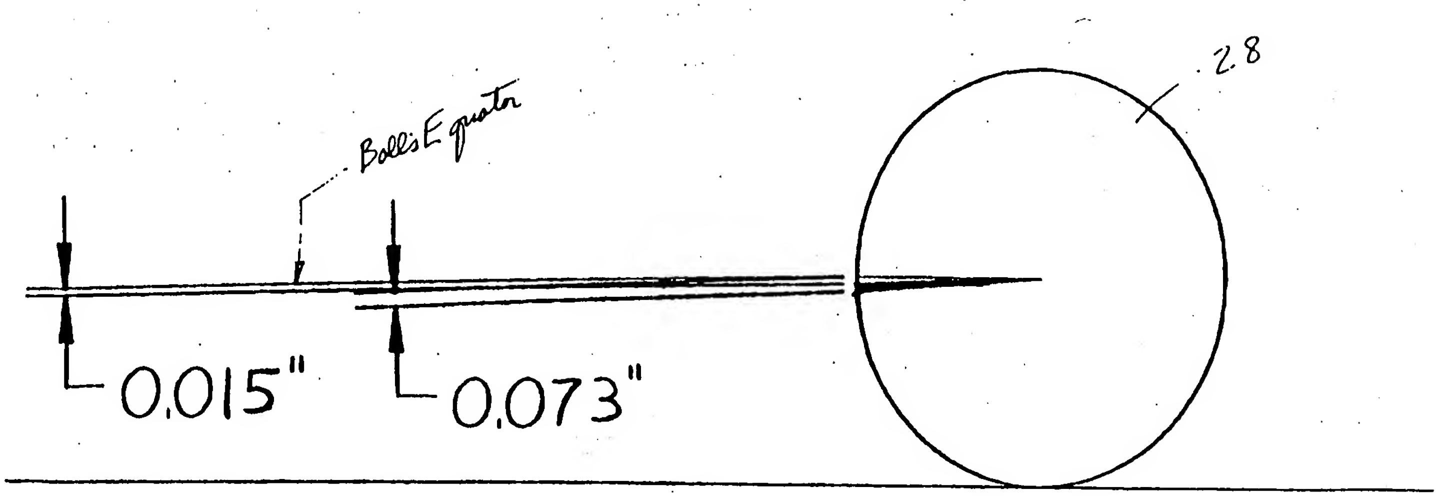


Fig. 11

Impact zone required to produce a putt that reduces skidding and optimizes true roll.
Impacts between 0.015" and 0.073" below the equator of the ball produce TRUE Roll.

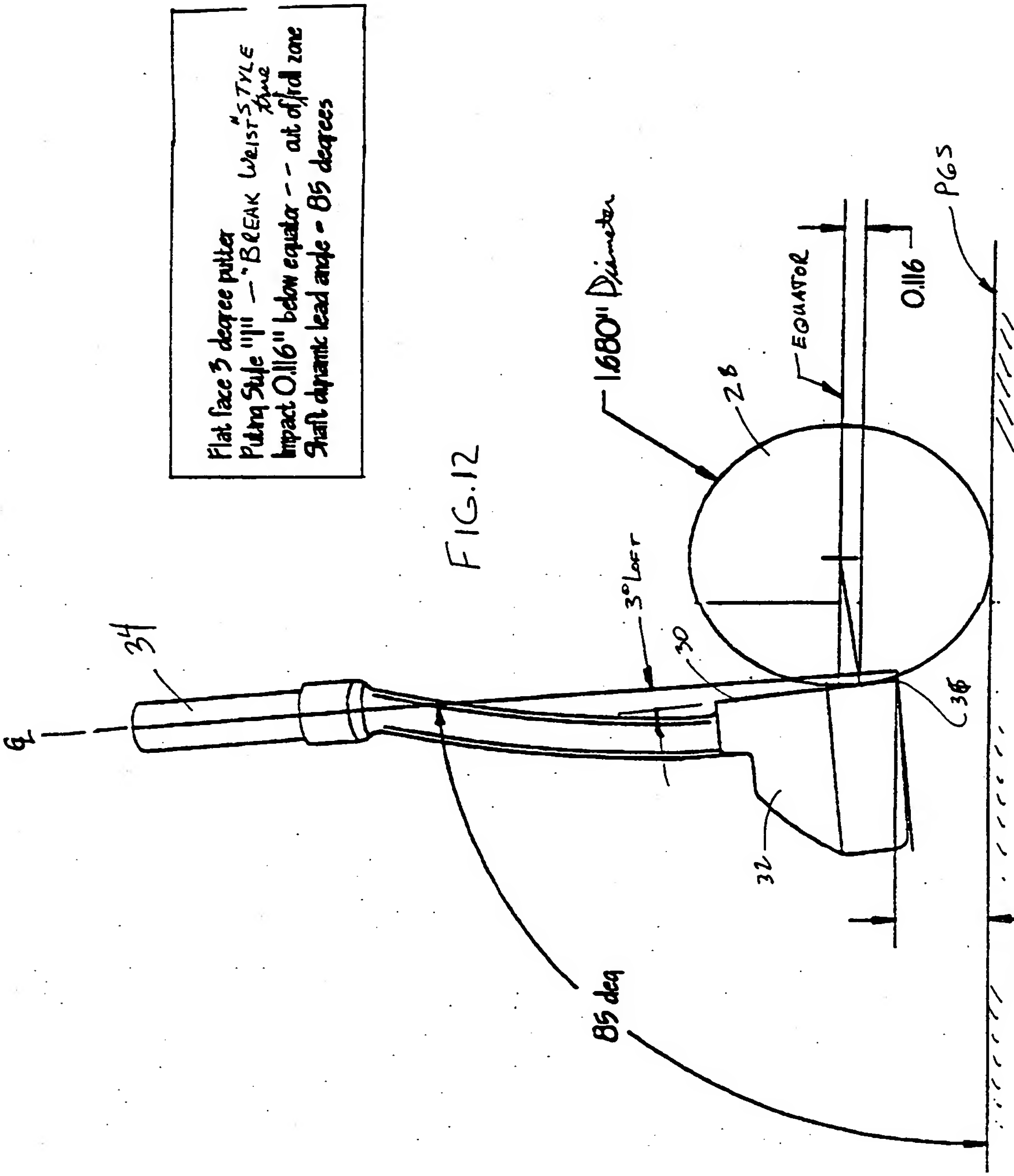

Flat face 3 degree putter
Putting Style "|||" — "BREAK WEIST" STYLE true
Impact 0.116" below equator - - out of roll zone
Shaft dynamic lead angle = 85 degrees
1.680" Diameter
28
EQUATOR
0.116
PGS
3° LOFT
30
34
36
32
85 deg
.389

FIG. 12

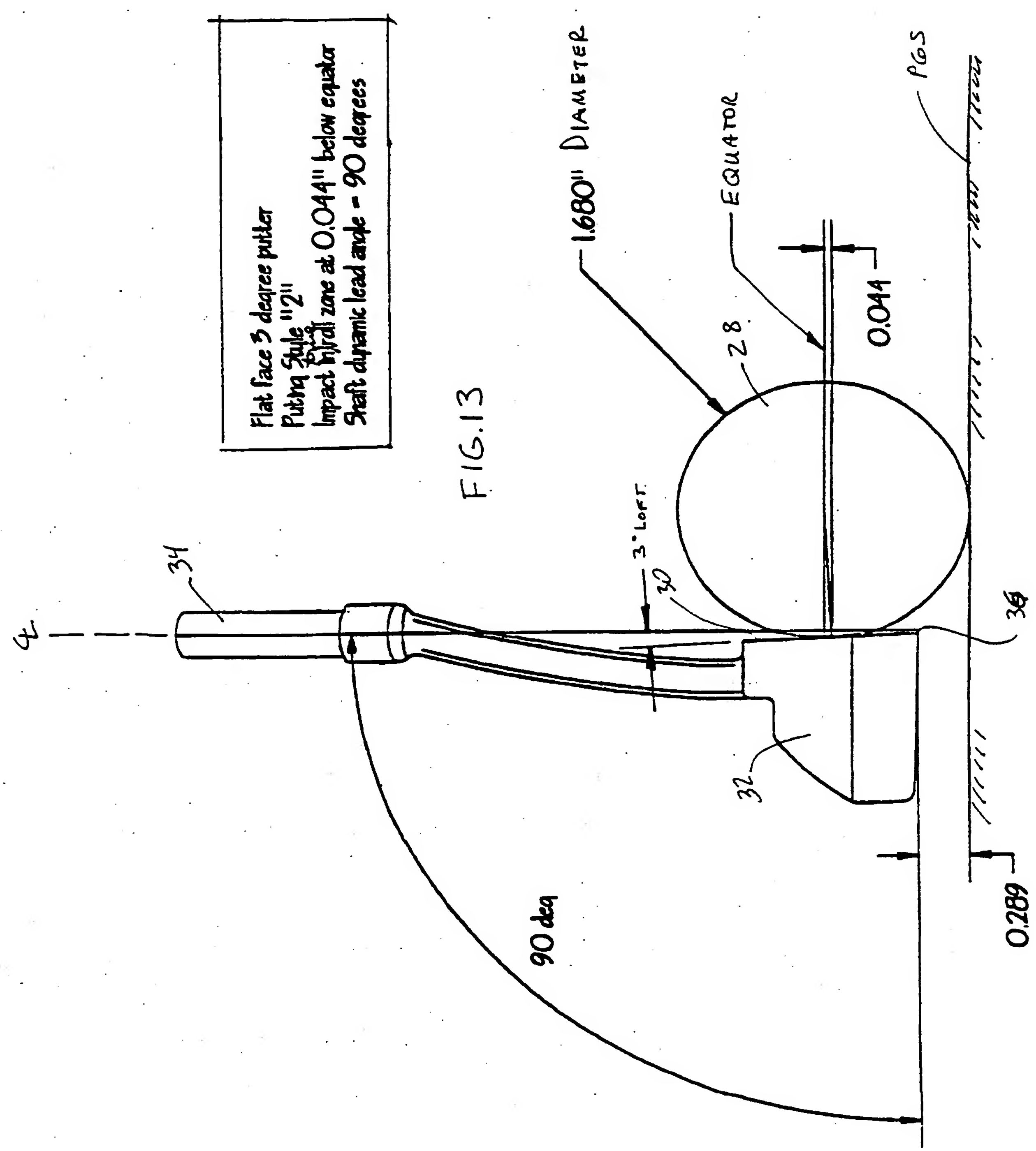

Flat face 3 degree putter
Putting Style "2"
Impact hyroll zone at 0.044" below equator
Shaft dynamic lead angle = 90 degrees
1.680" DIAMETER
EQUATOR
PGS
0.044
28
34
3° LOFT
30
36
32
90 deg
0.289

FIG. 13

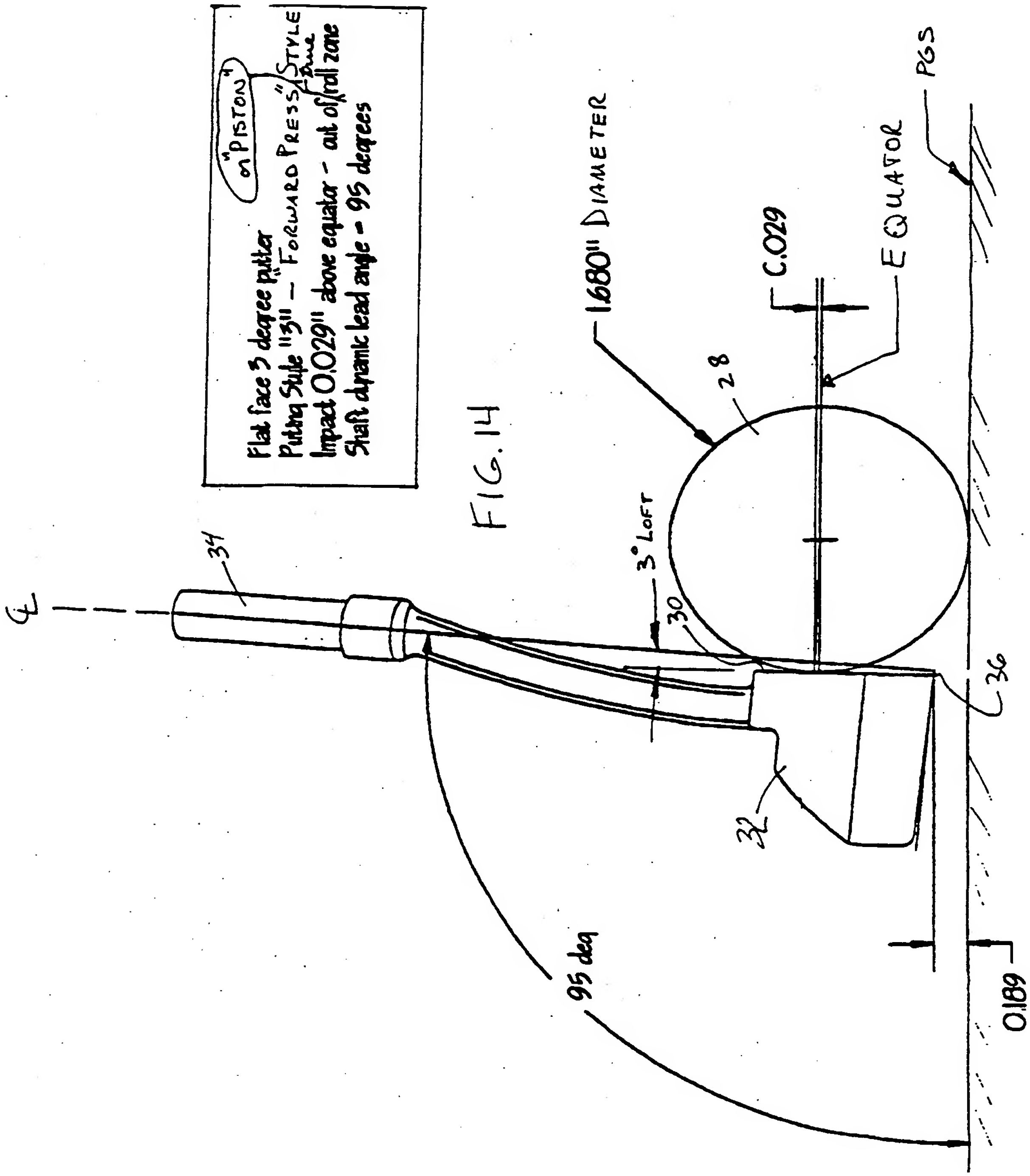

Flat face 3 degree putter
Putting Style "3" — "Forward Press" Style or "Piston"
Impact 0.029" above equator - out of true roll zone
Shaft dynamic lead angle = 95 degrees
1.680" DIAMETER
C.029
EQUATOR
PGS
28
34
30
3° LOFT
36
32
95 deg
0.189

FIG. 14

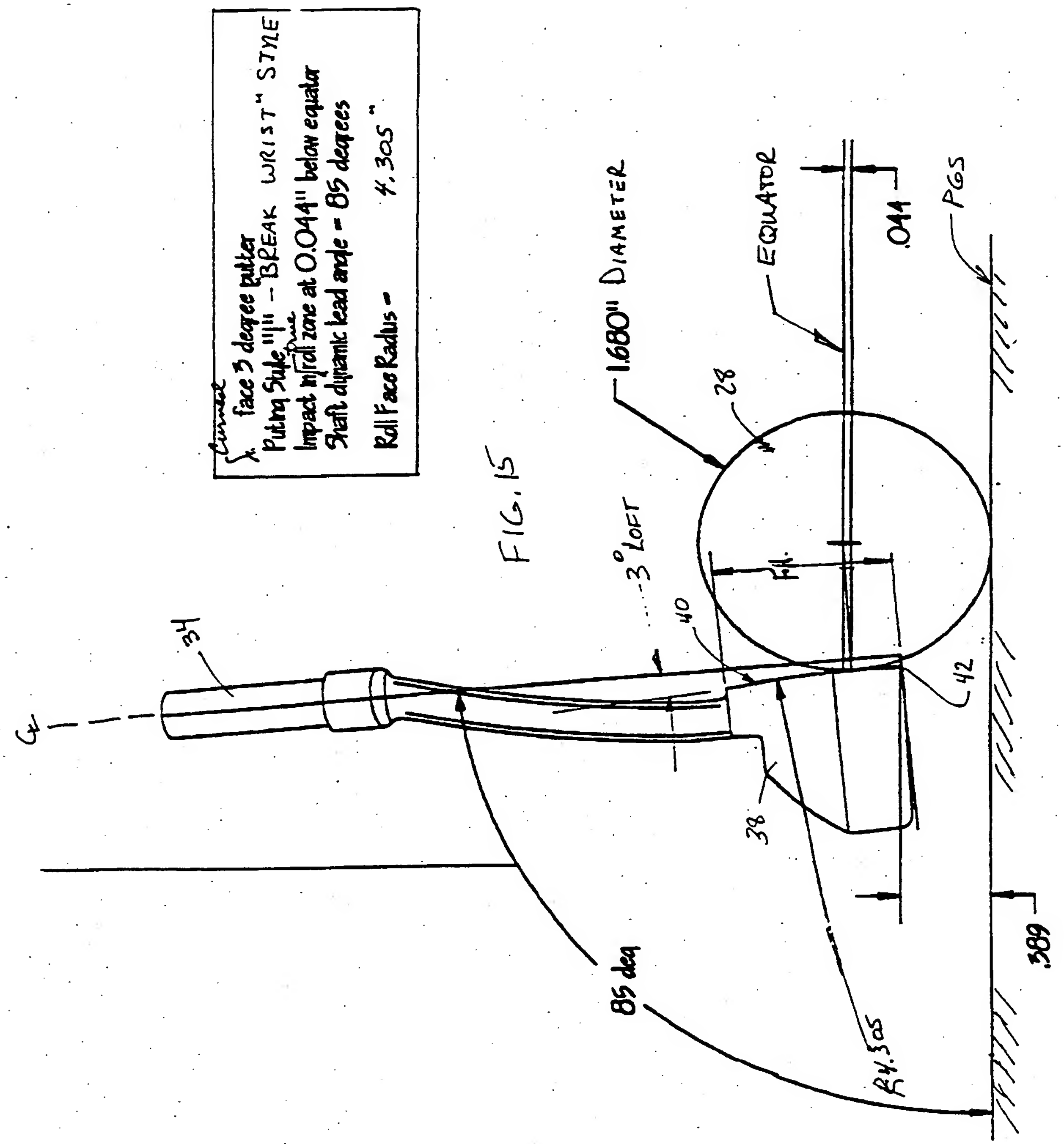

Current
Face 3 degree putter
Putting Style "I|I" – "BREAK WRIST" STYLE
Impact in true roll zone at 0.044" below equator
Shaft dynamic lead angle = 85 degrees
Roll Face Radius = 4.305"
1.680" DIAMETER
EQUATOR
.044
PGS
28
3° LOFT
40
34
42
38
85 deg
R4.305
.389

FIG. 15

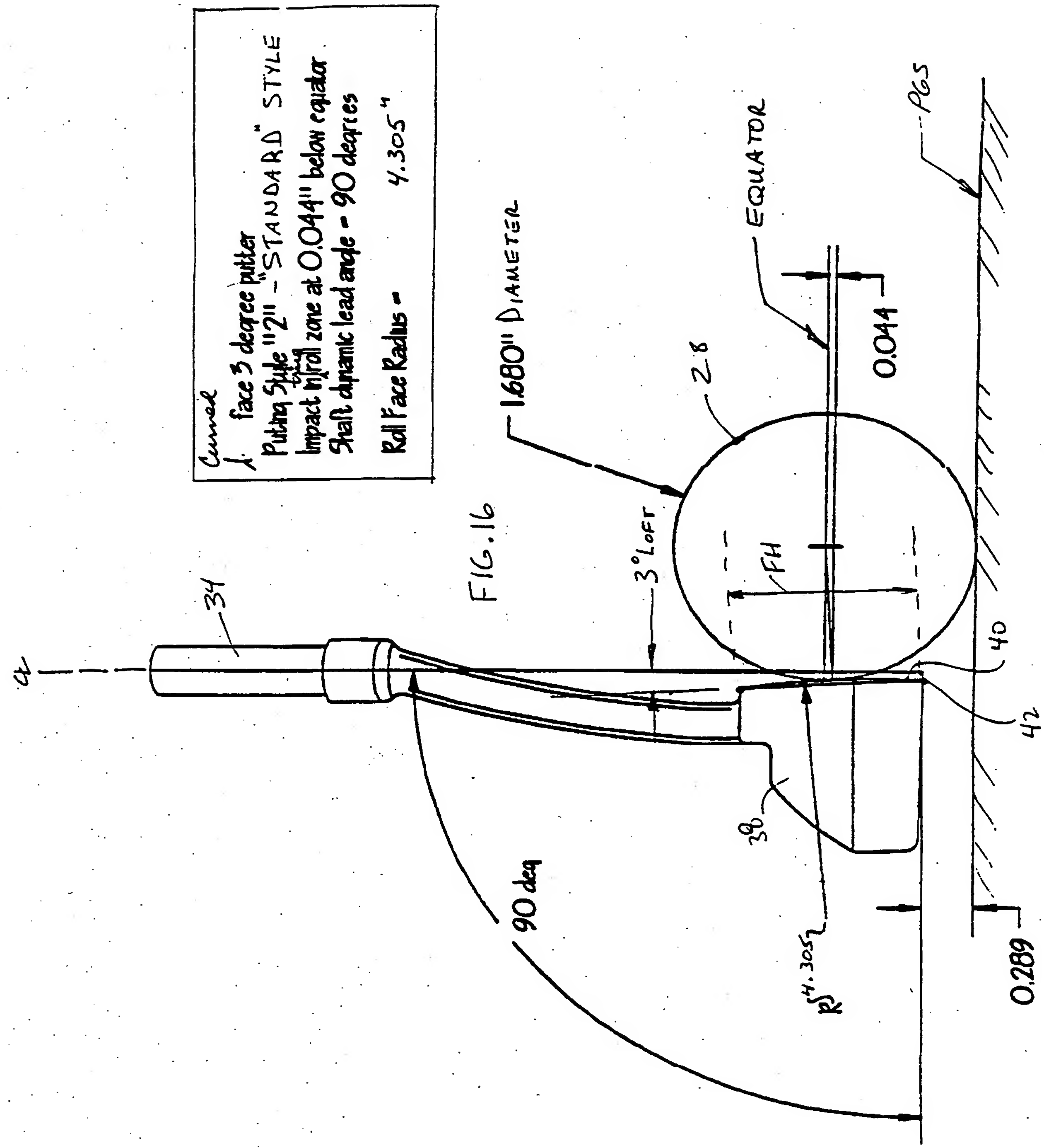

Curved
1. Face 3 degree putter
Putting Style "2" - "STANDARD" STYLE
Impact in/roll zone at 0.044" below equator
Shaft dynamic lead angle = 90 degrees
Roll Face Radius = 4.305"
1.680" DIAMETER
28
EQUATOR
PGS
0.044
3° LOFT
FH
34
α
40
42
38
90 deg
R4.305
0.289

FIG. 16

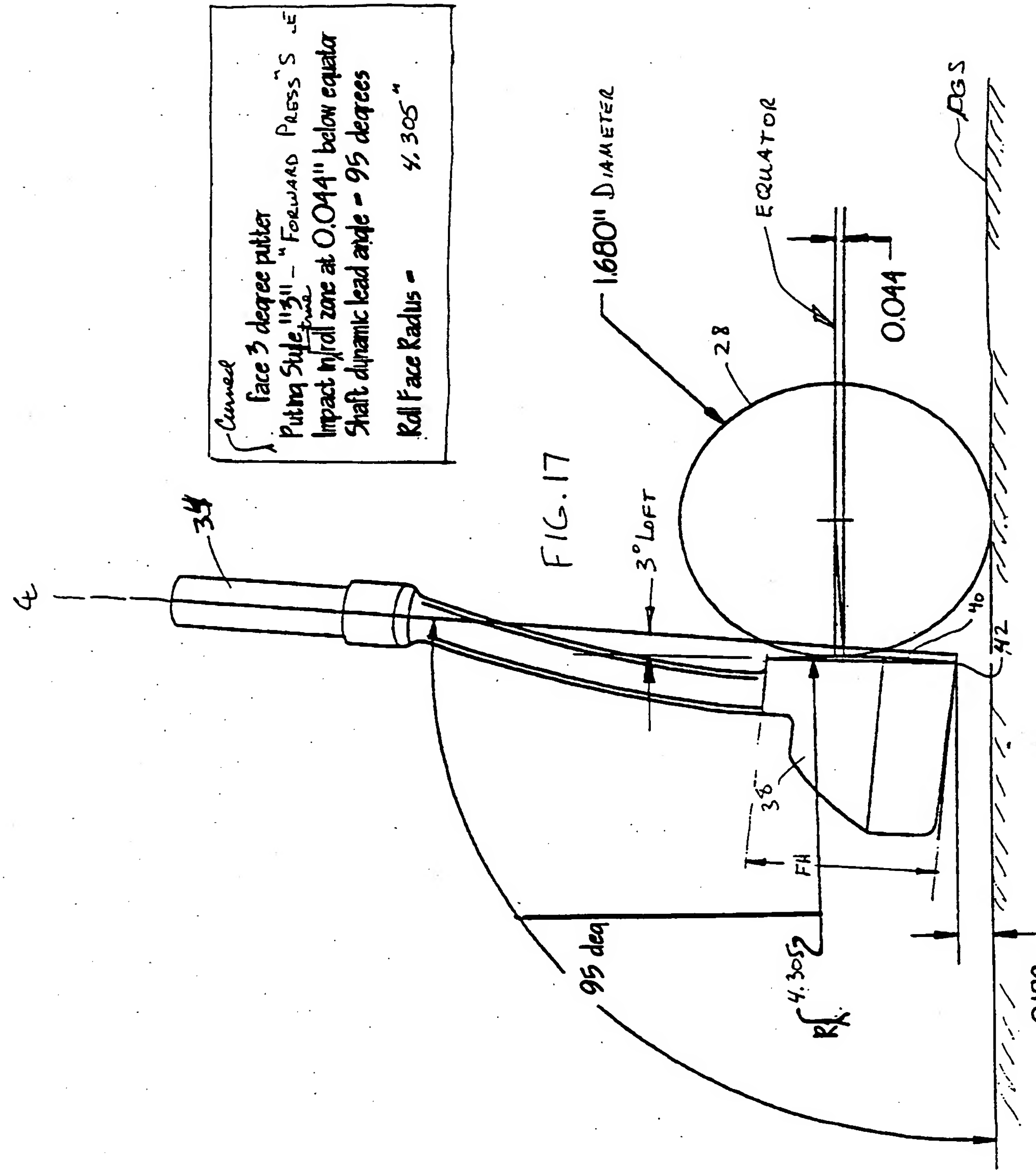

Curved
Face 3 degree putter
Putting Style "3" - "Forward Press" S
Impact in roll zone at 0.044" below equator
Shaft dynamic lead angle - 95 degrees
Roll Face Radius = 4.305"
1.680" DIAMETER
EQUATOR
28
0.044
RGS
3° LOFT
40
42
38
FH
95 deg
R 4.305
0.189
34

FIG. 17

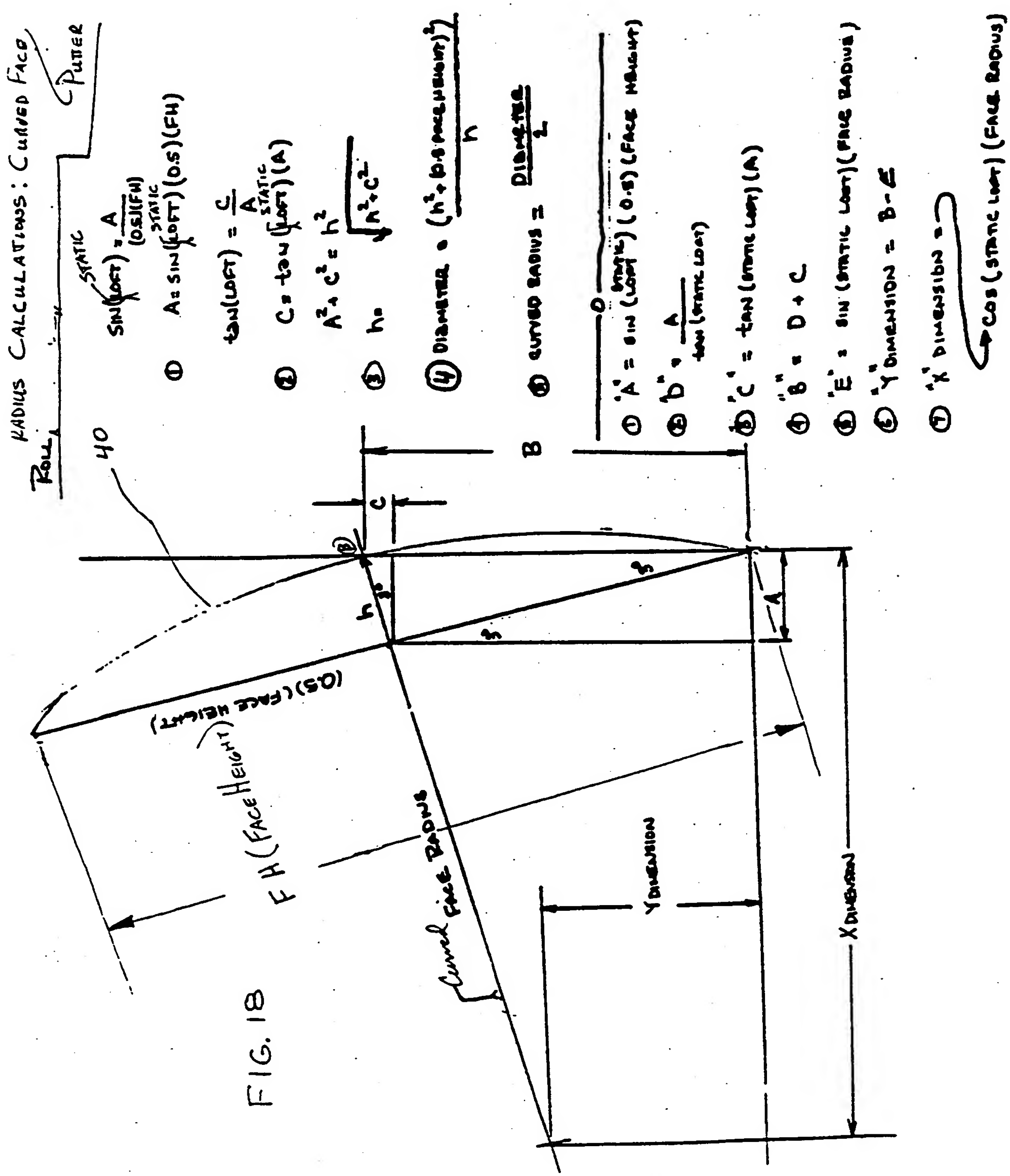

ROLL RADIUS CALCULATIONS: CURVED FACE
PUTTER
40
B
C
A
h
D
(0.5)(FACE HEIGHT)
FH (FACE HEIGHT)
CURVED FACE RADIUS
Y DIMENSION
X DIMENSION

FIG. 18

Equation :

*Face Radius = 4.782*Face Height +0.001166667* (for 3 degrees of loft in putter)

FIG.19

	Example Face HeightS	Resultant Face Radius	
	0.500	2.392	
	0.600	2.870	
0.750	0.700	3.349	3.588
	0.800	3.827	
	0.900	4.305	
	1.000	4.783	
	1.100	5.261	
1.250	1.200	5.740	5.979
	1.300	6.218	
	1.400	6.696	
	1.500	7.174	

OPTIMUM CURVED FACE ROLL RADII FOR GIVEN FACE HEIGHT

Loft Angle	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007
C=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K=	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007
Diameter=	28.649	31.514	34.379	37.244	40.109	42.974	45.839	48.704	51.569	54.434	57.299	60.164	63.029	65.893	68.758	71.623	74.488	77.353	80.218	83.083	85.948
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	14.324	15.757	17.189	18.621	20.054	21.486	22.919	24.351	25.783	27.216	28.648	30.081	31.513	32.945	34.378	35.810	37.243	38.675	40.108	41.540	42.972
Roll Radius	14.326	15.757	17.190	18.622	20.056	21.487	22.919	24.352	25.784	27.217	28.649	30.082	31.514	32.947	34.379	35.812	37.244	38.677	40.109	41.542	42.974

Loft Angle	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.012	0.012	0.013	0.013
C=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K=	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.012	0.012	0.013	0.013
Diameter=	14.327	15.760	17.192	18.625	20.058	21.490	22.923	24.356	25.788	27.221	28.654	30.086	31.519	32.952	34.384	35.817	37.250	38.683	40.115	41.548	42.981
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	7.162	7.879	8.595	9.311	10.027	10.744	11.460	12.176	12.892	13.608	14.325	15.041	15.757	16.473	17.190	17.906	18.622	19.338	20.055	20.771	21.487
Roll Radius	7.163	7.880	8.596	9.312	10.028	10.745	11.461	12.178	12.894	13.611	14.327	15.043	15.760	16.476	17.192	17.909	18.626	19.341	20.058	20.774	21.490

Loft Angle	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.007	0.007	0.008	0.009	0.009	0.010	0.010	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.016	0.016	0.017	0.018	0.018	0.019	0.020
C=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
K=	0.007	0.007	0.008	0.009	0.009	0.010	0.010	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.016	0.016	0.017	0.018	0.018	0.019	0.020
Diameter=	9.554	10.509	11.464	12.420	13.375	14.330	15.286	16.241	17.197	18.152	19.107	20.063	21.018	21.973	22.929	23.884	24.840	25.795	26.750	27.706	28.661
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	4.775	5.253	5.730	6.208	6.685	7.163	7.640	8.118	8.595	9.073	9.550	10.028	10.505	10.983	11.460	11.938	12.416	12.893	13.371	13.848	14.326
Roll Radius	4.777	5.256	5.732	6.210	6.688	7.166	7.643	8.121	8.599	9.076	9.554	10.031	10.509	10.987	11.464	11.942	12.420	12.897	13.375	13.853	14.330

FIG. 20A

-CONTINUED-

Loft Angle	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.009	0.010	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.024	0.025	0.026
C=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
h=	0.009	0.010	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.017	0.018	0.018	0.020	0.021	0.022	0.023	0.024	0.024	0.025	0.026
Diameter=	7.168	7.885	8.601	9.318	10.035	10.752	11.468	12.185	12.902	13.619	14.336	15.052	15.769	16.486	17.203	17.919	18.636	19.353	20.070	20.787	21.503
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600	0.625	0.650	0.675	0.700	0.725	0.750
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	3.582	3.940	4.298	4.656	5.014	5.373	5.731	6.089	6.447	6.805	7.163	7.522	7.880	8.238	8.596	8.954	9.312	9.671	10.029	10.387	10.745
Roll Radius	3.584	3.942	4.301	4.660	5.017	5.376	5.734	6.093	6.451	6.809	7.168	7.526	7.886	8.243	8.601	8.960	9.318	9.677	10.036	10.393	10.752

Loft Angle	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.031	0.032	0.033
C=	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
h=	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.031	0.032	0.033
Diameter=	5.737	6.311	6.884	7.458	8.032	8.605	9.179	9.753	10.326	10.900	11.474	12.047	12.621	13.195	13.768	14.342	14.916	15.490	16.063	16.637	17.211
D=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.548	0.574	0.599	0.624	0.649	0.674	0.699	0.724	0.749
B=	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.526	0.551	0.576	0.601	0.626	0.651	0.676	0.701	0.726	0.751
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.375
"X"=	2.868	3.152	3.439	3.725	4.012	4.298	4.585	4.872	5.158	5.445	5.739	6.018	6.305	6.591	6.878	7.164	7.451	7.737	8.024	8.311	8.597
Roll Radius	2.868	3.155	3.442	3.729	4.016	4.303	4.589	4.876	5.163	5.450	5.737	6.024	6.311	6.597	6.884	7.171	7.458	7.746	8.032	8.318	8.606

Loft Angle	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.013	0.014	0.016	0.017	0.018	0.020	0.021	0.022	0.024	0.025	0.026	0.027	0.028	0.030	0.031	0.033	0.034	0.035	0.037	0.038	0.039
C=	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.009	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
h=	0.013	0.014	0.016	0.017	0.018	0.020	0.021	0.022	0.024	0.025	0.026	0.026	0.028	0.030	0.031	0.033	0.034	0.035	0.037	0.038	0.039
Diameter=	4.783	5.262	5.740	6.218	6.697	7.175	7.653	8.132	8.610	9.088	9.567	10.045	10.523	11.002	11.480	11.958	12.437	12.915	13.393	13.872	14.350
D=	0.250	0.275	0.300	0.325	0.350	0.374	0.399	0.424	0.448	0.474	0.499	0.524	0.549	0.574	0.599	0.624	0.649	0.674	0.699	0.724	0.749
B=	0.250	0.275	0.300	0.325	0.350	0.376	0.401	0.426	0.451	0.476	0.501	0.526	0.551	0.576	0.601	0.626	0.651	0.676	0.701	0.726	0.751
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.376
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363	0.376
"X"=	2.388	2.627	2.866	3.105	3.344	3.583	3.821	4.060	4.299	4.538	4.777	5.016	5.255	5.493	5.732	5.971	6.210	6.449	6.688	6.926	7.165
Roll Radius	2.392	2.631	2.870	3.109	3.349	3.588	3.827	4.066	4.305	4.544	4.783	5.023	5.262	5.501	5.740	5.979	6.218	6.458	6.697	6.936	7.175

Loft Angle	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.015	0.017	0.018	0.020	0.021	0.023	0.024	0.026	0.027	0.029	0.031	0.032	0.034	0.035	0.037	0.038	0.040	0.041	0.043	0.044	0.046
C=	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003
h=	0.015	0.017	0.018	0.020	0.021	0.023	0.024	0.026	0.026	0.029	0.031	0.032	0.034	0.035	0.037	0.038	0.040	0.041	0.043	0.044	0.046
Diameter=	4.103	4.513	4.923	5.334	5.744	6.154	6.564	6.975	7.385	7.795	8.206	8.616	9.026	9.436	9.847	10.257	10.667	11.077	11.488	11.898	12.308
D=	0.250	0.274	0.299	0.324	0.349	0.374	0.399	0.424	0.449	0.474	0.499	0.524	0.549	0.574	0.599	0.624	0.649	0.674	0.699	0.724	0.749
B=	0.250	0.276	0.301	0.326	0.351	0.376	0.401	0.426	0.451	0.476	0.501	0.526	0.551	0.576	0.601	0.626	0.651	0.676	0.701	0.726	0.751
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.276	0.288	0.301	0.313	0.326	0.338	0.351	0.363	0.376
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.276	0.288	0.301	0.313	0.326	0.338	0.351	0.363	0.376
"X"=	2.048	2.252	2.457	2.662	2.867	3.071	3.276	3.481	3.686	3.890	4.095	4.300	4.505	4.709	4.914	5.119	5.324	5.528	5.733	5.938	6.143
Roll Radius	2.051	2.257	2.462	2.667	2.872	3.077	3.282	3.487	3.692	3.898	4.103	4.308	4.513	4.718	4.923	5.129	5.334	5.539	5.744	5.949	6.154

FIG. 20B.

-CONTINUED-

Loft Angle	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.017	0.019	0.021	0.023	0.024	0.026	0.028	0.030	0.031	0.033	0.035	0.037	0.038	0.040	0.042	0.044	0.045	0.047	0.049	0.051	0.052
C=	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004
h=	0.017	0.019	0.021	0.023	0.024	0.026	0.028	0.030	0.031	0.033	0.035	0.037	0.038	0.040	0.042	0.044	0.045	0.047	0.049	0.051	0.052
Diameter=	3.593	3.952	4.311	4.670	5.030	5.389	5.748	6.108	6.467	6.826	7.185	7.545	7.904	8.263	8.622	8.982	9.341	9.700	10.059	10.419	10.778
D=	0.249	0.274	0.299	0.324	0.349	0.374	0.399	0.424	0.449	0.474	0.499	0.524	0.549	0.574	0.599	0.623	0.648	0.673	0.698	0.723	0.748
B=	0.251	0.276	0.301	0.326	0.351	0.376	0.401	0.426	0.451	0.476	0.501	0.526	0.551	0.576	0.601	0.627	0.652	0.677	0.702	0.727	0.752
E=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313	0.326	0.338	0.351	0.363	0.376
"Y"=	0.125	0.138	0.150	0.163	0.175	0.188	0.200	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313	0.326	0.338	0.351	0.363	0.376
"X"=	1.792	1.971	2.150	2.330	2.509	2.688	2.867	3.046	3.226	3.405	3.584	3.763	3.942	4.121	4.301	4.480	4.659	4.838	5.017	5.197	5.376
Roll Radius	1.796	1.976	2.156	2.335	2.515	2.694	2.874	3.054	3.233	3.413	3.593	3.772	3.952	4.132	4.311	4.491	4.670	4.850	5.030	5.209	5.389

Loft Angle	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.020	0.022	0.024	0.025	0.027	0.029	0.031	0.033	0.035	0.037	0.039	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.055	0.057	0.059
C=	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005
h=	0.020	0.022	0.024	0.026	0.028	0.030	0.031	0.033	0.035	0.037	0.039	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.055	0.057	0.059
Diameter=	3.196	3.516	3.835	4.155	4.475	4.794	5.114	5.434	5.753	6.073	6.392	6.712	7.032	7.351	7.671	7.991	8.310	8.630	8.949	9.269	9.589
D=	0.249	0.274	0.299	0.324	0.349	0.374	0.399	0.424	0.449	0.474	0.498	0.523	0.548	0.573	0.598	0.623	0.648	0.673	0.698	0.723	0.748
B=	0.251	0.276	0.301	0.326	0.351	0.376	0.401	0.426	0.451	0.476	0.502	0.527	0.552	0.577	0.602	0.627	0.652	0.677	0.702	0.727	0.752
E=	0.125	0.138	0.150	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313	0.326	0.339	0.351	0.364	0.376
"Y"=	0.125	0.138	0.150	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313	0.326	0.339	0.351	0.364	0.376
"X"=	1.593	1.753	1.912	2.071	2.230	2.390	2.549	2.708	2.868	3.027	3.186	3.346	3.505	3.664	3.824	3.983	4.142	4.302	4.461	4.620	4.780
Roll Radius	1.598	1.758	1.918	2.078	2.237	2.397	2.557	2.717	2.877	3.036	3.196	3.356	3.516	3.676	3.836	3.996	4.155	4.315	4.475	4.635	4.794

Loft Angle	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.022	0.024	0.026	0.028	0.031	0.033	0.035	0.037	0.039	0.041	0.044	0.046	0.048	0.050	0.052	0.054	0.057	0.059	0.061	0.063	0.065
C=	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006
h=	0.022	0.024	0.026	0.028	0.031	0.033	0.035	0.037	0.039	0.042	0.044	0.046	0.048	0.050	0.052	0.055	0.057	0.059	0.061	0.063	0.065
Diameter=	2.879	3.167	3.455	3.743	4.031	4.319	4.607	4.895	5.183	5.471	5.759	6.047	6.335	6.623	6.911	7.199	7.486	7.774	8.062	8.350	8.638
D=	0.249	0.274	0.299	0.324	0.349	0.374	0.398	0.423	0.448	0.473	0.498	0.523	0.548	0.573	0.598	0.623	0.648	0.672	0.697	0.722	0.747
B=	0.251	0.276	0.301	0.326	0.351	0.376	0.402	0.427	0.452	0.477	0.502	0.527	0.552	0.577	0.602	0.627	0.652	0.678	0.703	0.728	0.753
E=	0.125	0.138	0.151	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.264	0.276	0.289	0.301	0.314	0.326	0.339	0.351	0.364	0.376
"Y"=	0.125	0.138	0.151	0.163	0.176	0.188	0.201	0.213	0.226	0.238	0.251	0.264	0.276	0.289	0.301	0.314	0.326	0.339	0.351	0.364	0.376
"X"=	1.434	1.578	1.721	1.864	2.008	2.151	2.295	2.438	2.582	2.725	2.868	3.012	3.155	3.299	3.442	3.586	3.729	3.872	4.016	4.159	4.303
Roll Radius	1.440	1.584	1.728	1.872	2.016	2.160	2.304	2.447	2.591	2.736	2.879	3.023	3.167	3.311	3.456	3.599	3.743	3.887	4.031	4.175	4.319

Loft Angle	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.024	0.026	0.029	0.031	0.034	0.036	0.038	0.041	0.043	0.046	0.048	0.050	0.053	0.055	0.058	0.060	0.062	0.065	0.067	0.069	0.072
C=	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007
h=	0.024	0.026	0.029	0.031	0.034	0.036	0.039	0.041	0.043	0.046	0.048	0.051	0.053	0.055	0.058	0.060	0.063	0.065	0.067	0.070	0.072
Diameter=	2.620	2.882	3.145	3.407	3.669	3.931	4.193	4.455	4.717	4.979	5.241	5.503	5.765	6.027	6.289	6.551	6.813	7.075	7.337	7.599	7.861
D=	0.249	0.274	0.299	0.324	0.348	0.373	0.398	0.423	0.448	0.473	0.498	0.523	0.547	0.572	0.597	0.622	0.647	0.672	0.697	0.722	0.747
B=	0.251	0.276	0.301	0.327	0.352	0.377	0.402	0.427	0.452	0.477	0.502	0.527	0.553	0.578	0.603	0.628	0.653	0.678	0.703	0.728	0.753
E=	0.126	0.138	0.151	0.163	0.176	0.188	0.201	0.213	0.226	0.239	0.251	0.264	0.276	0.289	0.301	0.314	0.327	0.339	0.352	0.364	0.377
"Y"=	0.126	0.138	0.151	0.163	0.176	0.188	0.201	0.213	0.226	0.239	0.251	0.264	0.276	0.289	0.301	0.314	0.327	0.339	0.352	0.364	0.377
"X"=	1.304	1.435	1.565	1.696	1.826	1.956	2.087	2.217	2.348	2.478	2.608	2.739	2.869	3.000	3.130	3.260	3.391	3.521	3.652	3.782	3.913
Roll Radius	1.310	1.441	1.572	1.703	1.834	1.965	2.096	2.227	2.358	2.489	2.620	2.751	2.882	3.013	3.144	3.275	3.407	3.538	3.669	3.800	3.931

FIG. 20C

-CONTINUED-

Loft Angle	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.026	0.029	0.031	0.034	0.037	0.039	0.042	0.044	0.047	0.050	0.052	0.055	0.057	0.060	0.063	0.065	0.068	0.071	0.073	0.076	0.078
C=	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008
h=	0.026	0.029	0.032	0.034	0.037	0.039	0.042	0.045	0.047	0.050	0.053	0.055	0.058	0.060	0.063	0.066	0.068	0.071	0.074	0.076	0.079
Diameter=	2.405	2.645	2.886	3.126	3.367	3.607	3.848	4.088	4.329	4.569	4.810	5.050	5.291	5.531	5.772	6.012	6.253	6.493	6.734	6.974	7.215
D=	0.249	0.273	0.298	0.323	0.348	0.373	0.398	0.423	0.448	0.472	0.497	0.522	0.547	0.572	0.597	0.622	0.646	0.671	0.696	0.721	0.746
B=	0.251	0.277	0.302	0.327	0.352	0.377	0.402	0.427	0.452	0.478	0.503	0.528	0.553	0.578	0.603	0.628	0.654	0.679	0.704	0.729	0.754
E=	0.126	0.138	0.151	0.163	0.176	0.189	0.201	0.214	0.226	0.239	0.251	0.264	0.277	0.289	0.302	0.314	0.327	0.339	0.352	0.364	0.377
"Y"=	0.126	0.138	0.151	0.163	0.176	0.189	0.201	0.214	0.226	0.239	0.251	0.264	0.277	0.289	0.302	0.314	0.327	0.339	0.352	0.364	0.377
"X"=	1.196	1.315	1.435	1.556	1.674	1.794	1.913	2.033	2.153	2.272	2.392	2.511	2.631	2.750	2.870	2.990	3.109	3.229	3.348	3.468	3.588
Roll Radius	1.202	1.323	1.443	1.563	1.683	1.804	1.924	2.044	2.164	2.285	2.405	2.526	2.646	2.766	2.886	3.006	3.126	3.247	3.367	3.487	3.607

Loft Angle	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.028	0.031	0.034	0.037	0.040	0.042	0.045	0.048	0.051	0.054	0.057	0.059	0.062	0.065	0.068	0.071	0.074	0.076	0.079	0.082	0.085
C=	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.010
h=	0.028	0.031	0.034	0.037	0.040	0.043	0.046	0.048	0.051	0.054	0.057	0.060	0.063	0.066	0.068	0.071	0.074	0.077	0.080	0.083	0.085
Diameter=	2.223	2.445	2.667	2.890	3.112	3.334	3.556	3.779	4.001	4.223	4.445	4.668	4.890	5.112	5.334	5.557	5.779	6.001	6.224	6.446	6.668
D=	0.248	0.273	0.298	0.323	0.348	0.373	0.397	0.422	0.447	0.472	0.497	0.522	0.546	0.571	0.596	0.621	0.646	0.671	0.696	0.720	0.745
B=	0.252	0.277	0.302	0.327	0.352	0.377	0.403	0.428	0.453	0.478	0.503	0.528	0.554	0.579	0.604	0.629	0.654	0.679	0.705	0.730	0.755
E=	0.126	0.138	0.151	0.164	0.176	0.189	0.201	0.214	0.226	0.239	0.252	0.264	0.277	0.289	0.302	0.315	0.327	0.340	0.352	0.365	0.377
"Y"=	0.126	0.138	0.151	0.164	0.176	0.189	0.201	0.214	0.226	0.239	0.252	0.264	0.277	0.289	0.302	0.315	0.327	0.340	0.352	0.365	0.377
"X"=	1.104	1.215	1.325	1.436	1.546	1.656	1.767	1.877	1.988	2.098	2.208	2.319	2.429	2.540	2.650	2.761	2.871	2.981	3.092	3.202	3.313
Roll Radius	1.111	1.222	1.334	1.445	1.556	1.667	1.778	1.889	2.000	2.112	2.223	2.334	2.445	2.556	2.667	2.778	2.890	3.001	3.112	3.223	3.334

Loft Angle	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.030	0.034	0.037	0.040	0.043	0.046	0.049	0.052	0.055	0.058	0.061	0.064	0.067	0.070	0.073	0.076	0.079	0.082	0.085	0.088	0.091
C=	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.011	0.011
h=	0.031	0.034	0.037	0.040	0.043	0.046	0.049	0.052	0.055	0.058	0.061	0.064	0.068	0.071	0.074	0.077	0.080	0.083	0.086	0.089	0.092
Diameter=	2.067	2.273	2.480	2.687	2.893	3.100	3.307	3.514	3.720	3.927	4.134	4.340	4.547	4.754	4.960	5.167	5.374	5.580	5.787	5.994	6.200
D=	0.248	0.273	0.298	0.323	0.347	0.372	0.397	0.422	0.447	0.471	0.496	0.521	0.546	0.571	0.596	0.620	0.645	0.670	0.695	0.720	0.744
B=	0.252	0.277	0.302	0.327	0.353	0.378	0.403	0.428	0.453	0.478	0.504	0.529	0.554	0.579	0.605	0.630	0.655	0.680	0.705	0.730	0.756
E=	0.126	0.139	0.151	0.164	0.176	0.189	0.202	0.214	0.227	0.239	0.252	0.264	0.277	0.290	0.302	0.315	0.327	0.340	0.353	0.365	0.378
"Y"=	0.126	0.139	0.151	0.164	0.176	0.189	0.202	0.214	0.227	0.239	0.252	0.264	0.277	0.290	0.302	0.315	0.327	0.340	0.353	0.365	0.378
"X"=	1.026	1.128	1.231	1.333	1.436	1.539	1.641	1.744	1.846	1.949	2.051	2.154	2.257	2.359	2.462	2.564	2.667	2.769	2.872	2.974	3.077
Roll Radius	1.033	1.137	1.240	1.343	1.447	1.550	1.653	1.757	1.860	1.963	2.067	2.170	2.273	2.377	2.480	2.583	2.687	2.790	2.893	2.997	3.100

Loft Angle	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.033	0.036	0.039	0.042	0.046	0.049	0.052	0.055	0.059	0.062	0.065	0.069	0.072	0.075	0.078	0.082	0.085	0.088	0.091	0.095	0.098
C=	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.010	0.010	0.011	0.011	0.012	0.012	0.012	0.013
h=	0.033	0.036	0.039	0.043	0.046	0.049	0.053	0.056	0.059	0.063	0.066	0.069	0.072	0.076	0.079	0.082	0.086	0.089	0.092	0.095	0.099
Diameter=	1.932	2.125	2.318	2.511	2.705	2.898	3.091	3.284	3.477	3.671	3.864	4.057	4.250	4.443	4.636	4.830	5.023	5.216	5.409	5.602	5.796
D=	0.248	0.273	0.297	0.322	0.347	0.372	0.397	0.421	0.446	0.471	0.496	0.521	0.545	0.570	0.595	0.620	0.644	0.669	0.694	0.719	0.744
B=	0.252	0.277	0.303	0.328	0.353	0.378	0.403	0.429	0.454	0.479	0.504	0.530	0.555	0.580	0.605	0.630	0.656	0.681	0.706	0.731	0.756
E=	0.126	0.139	0.151	0.164	0.177	0.189	0.202	0.214	0.227	0.240	0.252	0.265	0.277	0.290	0.303	0.315	0.328	0.340	0.353	0.366	0.378
"Y"=	0.126	0.139	0.151	0.164	0.177	0.189	0.202	0.214	0.227	0.240	0.252	0.265	0.277	0.290	0.303	0.315	0.328	0.340	0.353	0.366	0.378
"X"=	0.958	1.053	1.149	1.245	1.341	1.436	1.532	1.628	1.724	1.820	1.915	2.011	2.107	2.203	2.298	2.394	2.490	2.586	2.681	2.777	2.873
Roll Radius	0.966	1.063	1.159	1.256	1.352	1.449	1.546	1.642	1.739	1.836	1.932	2.028	2.125	2.222	2.318	2.415	2.511	2.608	2.705	2.801	2.898

FIG. 20D

-CONTINUED-

Loft Angle	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.035	0.038	0.042	0.045	0.049	0.052	0.056	0.059	0.063	0.066	0.070	0.073	0.077	0.080	0.084	0.087	0.090	0.094	0.097	0.101	0.104
C=	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.015
h=	0.035	0.039	0.042	0.046	0.049	0.053	0.056	0.060	0.063	0.067	0.070	0.074	0.077	0.081	0.084	0.088	0.091	0.095	0.098	0.102	0.105
Diameter=	1.814	1.995	2.177	2.358	2.540	2.721	2.902	3.084	3.265	3.447	3.628	3.809	3.991	4.172	4.354	4.535	4.716	4.898	5.079	5.261	5.442
D=	0.248	0.272	0.297	0.322	0.347	0.371	0.396	0.421	0.446	0.470	0.495	0.520	0.545	0.569	0.594	0.619	0.644	0.668	0.693	0.718	0.743
B=	0.252	0.278	0.303	0.328	0.353	0.379	0.404	0.429	0.454	0.480	0.505	0.530	0.555	0.581	0.606	0.631	0.656	0.682	0.707	0.732	0.757
E=	0.126	0.139	0.151	0.164	0.177	0.189	0.202	0.215	0.227	0.240	0.252	0.265	0.278	0.290	0.303	0.316	0.328	0.341	0.353	0.366	0.379
"Y"=	0.126	0.139	0.151	0.164	0.177	0.189	0.202	0.215	0.227	0.240	0.252	0.265	0.278	0.290	0.303	0.316	0.328	0.341	0.353	0.366	0.379
"X"=	0.898	0.988	1.078	1.168	1.257	1.347	1.437	1.527	1.617	1.707	1.796	1.886	1.976	2.066	2.156	2.245	2.335	2.425	2.515	2.605	2.694
Roll Radius	0.907	0.998	1.088	1.179	1.270	1.360	1.451	1.542	1.633	1.723	1.814	1.905	1.996	2.086	2.177	2.267	2.358	2.449	2.540	2.630	2.721

Loft Angle	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Face Height	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
Calculations																					
A=	0.037	0.041	0.044	0.048	0.052	0.055	0.059	0.063	0.067	0.070	0.074	0.078	0.081	0.085	0.089	0.092	0.096	0.100	0.103	0.107	0.111
C=	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.015	0.015	0.016	0.017
h=	0.037	0.041	0.045	0.048	0.052	0.056	0.060	0.064	0.067	0.071	0.075	0.078	0.082	0.086	0.090	0.093	0.097	0.101	0.105	0.108	0.112
Diameter=	1.710	1.881	2.052	2.223	2.394	2.565	2.736	2.907	3.078	3.249	3.420	3.591	3.762	3.933	4.104	4.275	4.446	4.617	4.788	4.959	5.130
D=	0.247	0.272	0.297	0.321	0.346	0.371	0.396	0.420	0.445	0.470	0.495	0.519	0.544	0.569	0.593	0.618	0.643	0.668	0.692	0.717	0.742
B=	0.253	0.278	0.303	0.329	0.354	0.379	0.404	0.430	0.455	0.480	0.506	0.531	0.556	0.581	0.607	0.632	0.657	0.682	0.708	0.733	0.758
E=	0.126	0.139	0.152	0.164	0.177	0.190	0.202	0.215	0.227	0.240	0.253	0.265	0.278	0.291	0.303	0.316	0.329	0.341	0.354	0.367	0.379
"Y"=	0.126	0.139	0.152	0.164	0.177	0.190	0.202	0.215	0.227	0.240	0.253	0.265	0.278	0.291	0.303	0.316	0.329	0.341	0.354	0.367	0.379
"X"=	0.846	0.930	1.015	1.099	1.184	1.269	1.353	1.438	1.522	1.607	1.691	1.776	1.861	1.945	2.030	2.114	2.199	2.283	2.368	2.452	2.537
Roll Radius	0.855	0.941	1.026	1.112	1.197	1.283	1.368	1.454	1.539	1.625	1.710	1.796	1.881	1.967	2.052	2.138	2.223	2.309	2.394	2.480	2.565

FIG. 20E

Summary Chart (Face Roll Radius)

FACE HEIGHT

LOFT ANGLE	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
0.5	14 325	15 757	17 190	18 622	20 055	21 487	22 919	24 352	25 784	27 217	28 649
1	7 163	7 880	8 596	9 312	10 028	10 745	11.461	12 178	12 894	13 611	14 327
1.5	4 777	5 255	5 732	6 210	6 688	7 165	7 643	8 121	8 598	9 076	9 554
2	3 584	3 942	4 301	4 659	5 017	5 376	5 734	6 093	6 451	6 809	7 168
2.5	2 868	3 155	3 442	3 728	4 015	4 302	4 589	4 876	5 163	5 450	5 737
3	2 392	2 631	2 870	3 109	3 348	3 588	3 827	4 066	4 305	4 544	4 783
3.5	2 051	2 257	2 462	2 667	2 872	3 077	3 282	3 487	3 692	3 898	4 103
4	1 796	1 976	2 156	2 335	2 515	2 694	2 874	3 054	3 233	3 413	3 593
4.5	1 598	1 758	1 918	2 078	2 237	2 397	2 557	2 717	2 877	3 036	3 196
5	1 440	1 584	1 728	1 872	2 016	2 160	2 304	2 447	2 591	2 735	2 879
5.5	1 310	1 441	1 572	1 703	1 834	1 965	2 096	2 227	2 358	2 489	2 620
6	1 202	1 323	1 443	1 563	1 683	1 804	1 924	2 044	2 164	2 285	2 405
6.5	1 111	1 222	1 334	1 445	1 556	1 667	1 778	1 889	2 000	2 112	2 223
7	1 033	1 137	1 240	1 343	1 447	1 550	1 653	1 757	1 860	1 963	2 067
7.5	0 966	1 063	1 159	1 256	1 352	1 449	1 545	1 642	1 738	1 835	1 932
8	0 907	0 998	1 088	1 179	1 270	1 360	1 451	1 542	1 633	1 723	1 814
8.5	0 855	0 941	1 026	1 112	1 197	1 283	1 368	1 454	1 539	1 625	1 710

LOFT ANGLE	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
0.5	30 082	31 514	32 947	34 379	35 812	37 244	38 677	40 109	41 542	42 974
1	15 043	15 760	16 476	17 192	17 909	18 625	19 341	20 058	20 774	21 490
1.5	10 031	10 509	10 987	11 464	11 942	12 420	12 897	13 375	13 853	14 330
2	7 526	7 885	8 243	8 601	8 960	9 318	9 677	10 035	10 393	10 752
2.5	6 024	6 311	6 597	6 884	7 171	7 458	7 745	8 032	8 318	8 605
3	5 023	5 262	5 501	5 740	5 979	6 218	6 458	6 697	6 936	7 175
3.5	4 308	4 513	4 718	4 923	5 128	5 334	5 539	5 744	5 949	6 154
4	3 772	3 952	4 132	4 311	4 491	4 670	4 850	5 030	5 209	5 389
4.5	3 356	3 516	3 676	3 835	3 995	4 155	4 315	4 475	4 635	4 794
5	3 023	3 167	3 311	3 455	3 599	3 743	3 887	4 031	4 175	4 319
5.5	2 751	2 882	3 013	3 145	3 276	3 407	3 538	3 669	3 800	3 931
6	2 525	2 645	2 766	2 886	3 006	3 126	3 247	3 367	3 487	3 607
6.5	2 334	2 445	2 556	2 667	2 778	2 890	3 001	3 112	3 223	3 334
7	2 170	2 273	2 377	2 480	2 583	2 687	2 790	2 893	2 997	3 100
7.5	2 028	2 125	2 222	2 318	2 415	2 511	2 608	2 705	2 801	2 898
8	1 905	1 995	2 086	2 177	2 267	2 358	2 449	2 540	2 630	2 721
8.5	1 796	1 881	1.967	2 052	2 138	2 223	2 309	2 394	2 480	2 565

FIG. 21

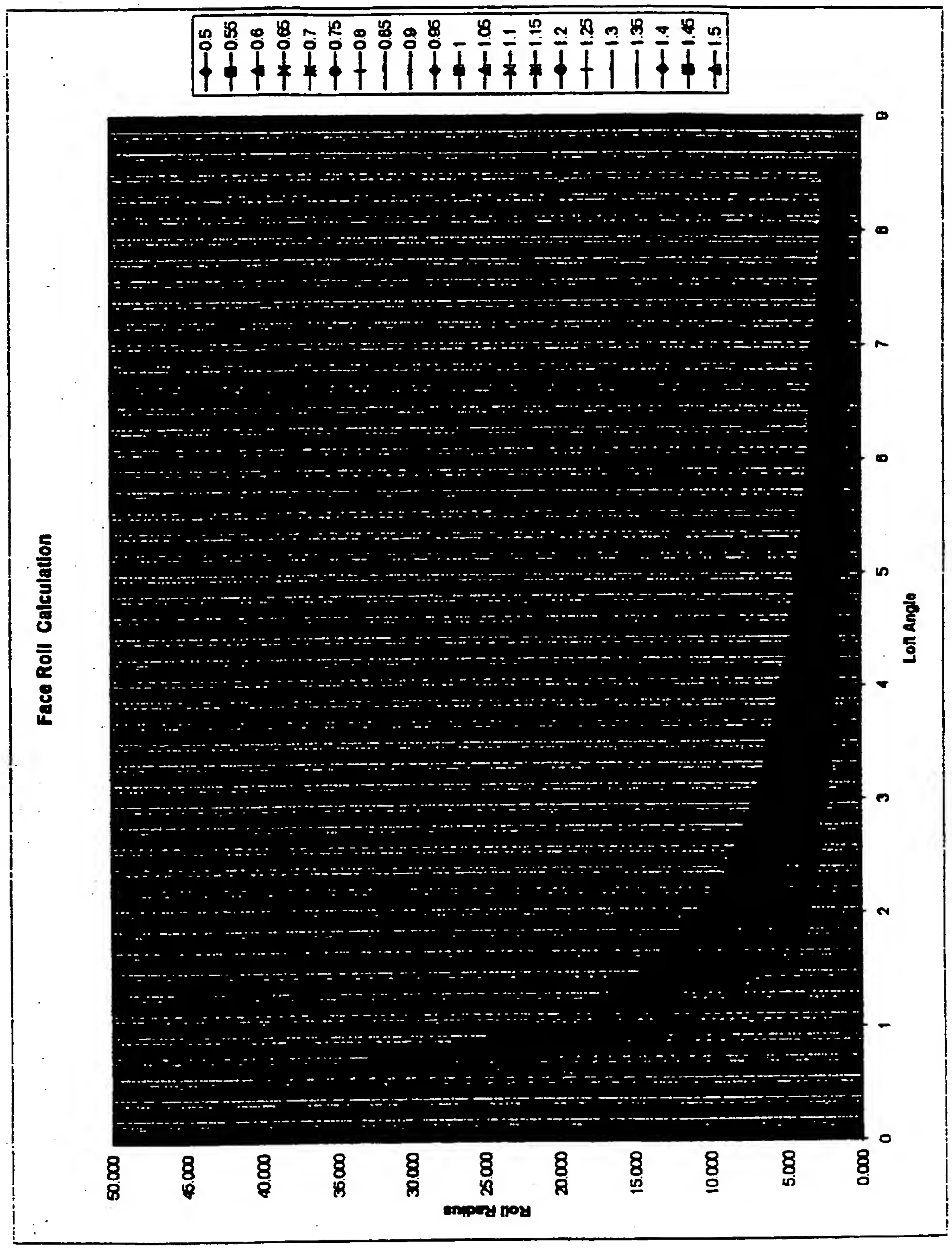

Face Roll Calculation
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
1.3
1.35
1.4
1.45
1.5
50.000
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0.000
Roll Radius
0
1
2
3
4
5
6
7
8
9
Loft Angle

FIG. 22

FIG. 23

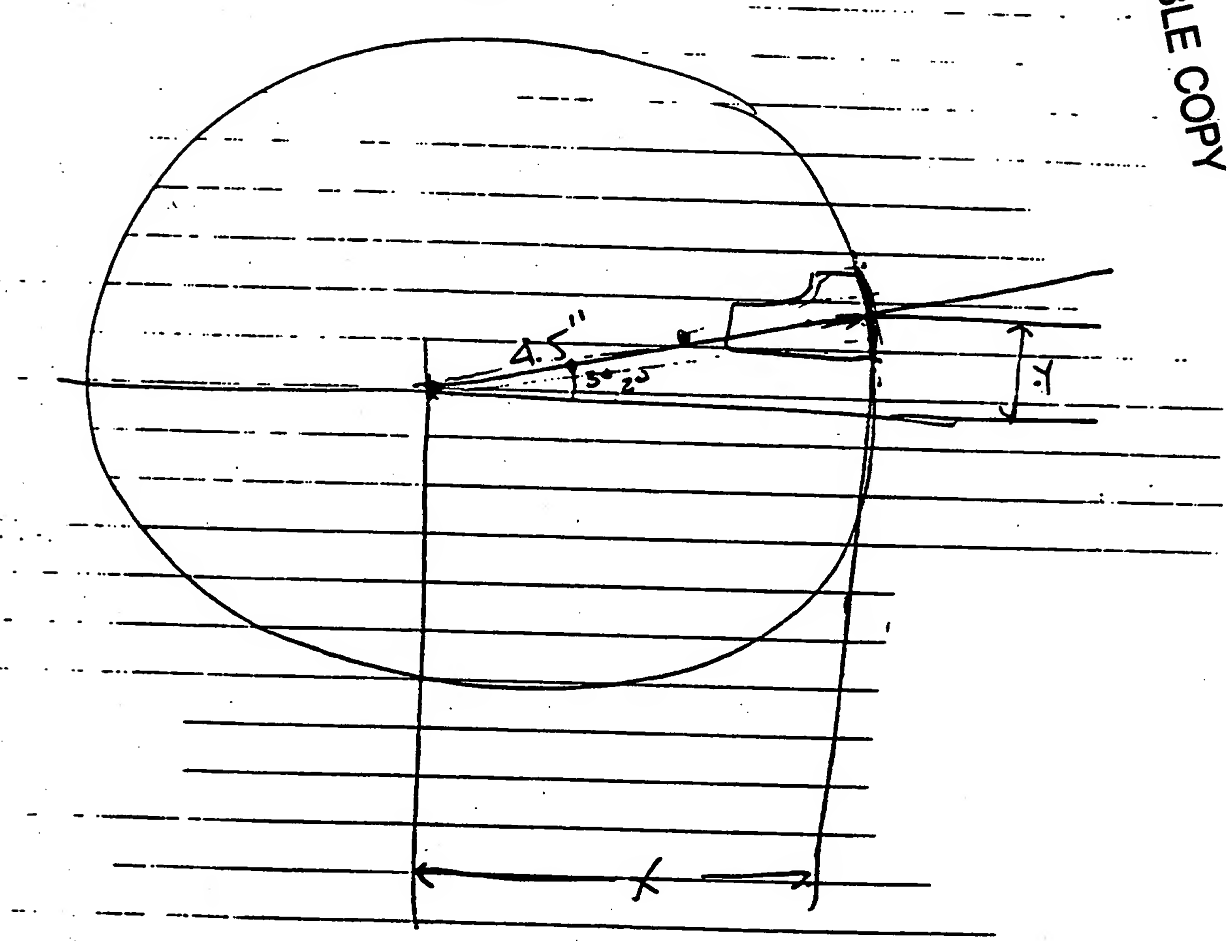
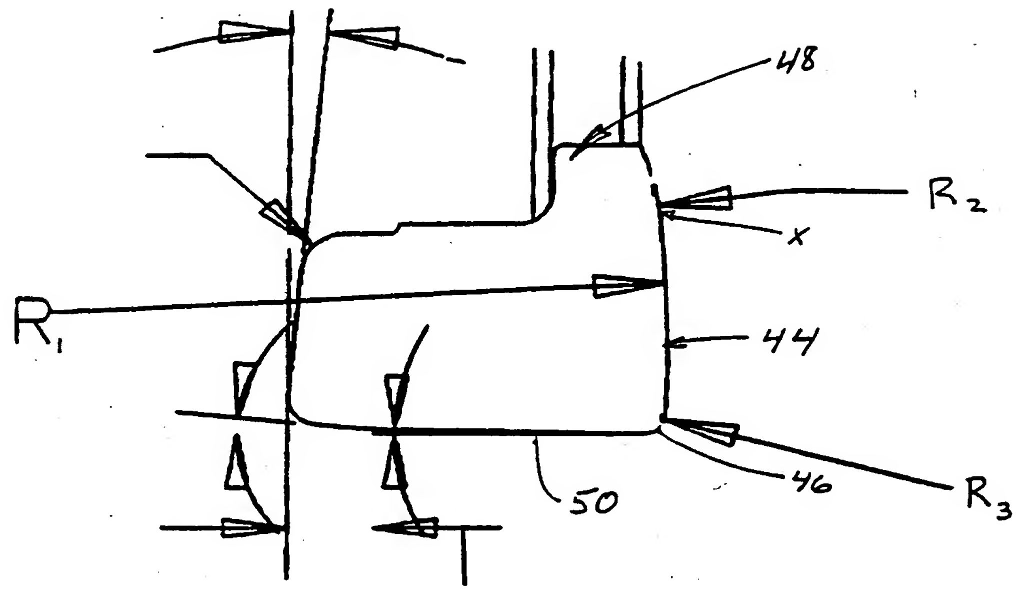


FIG.24


48
R2
X
R1
44
50
46
R3

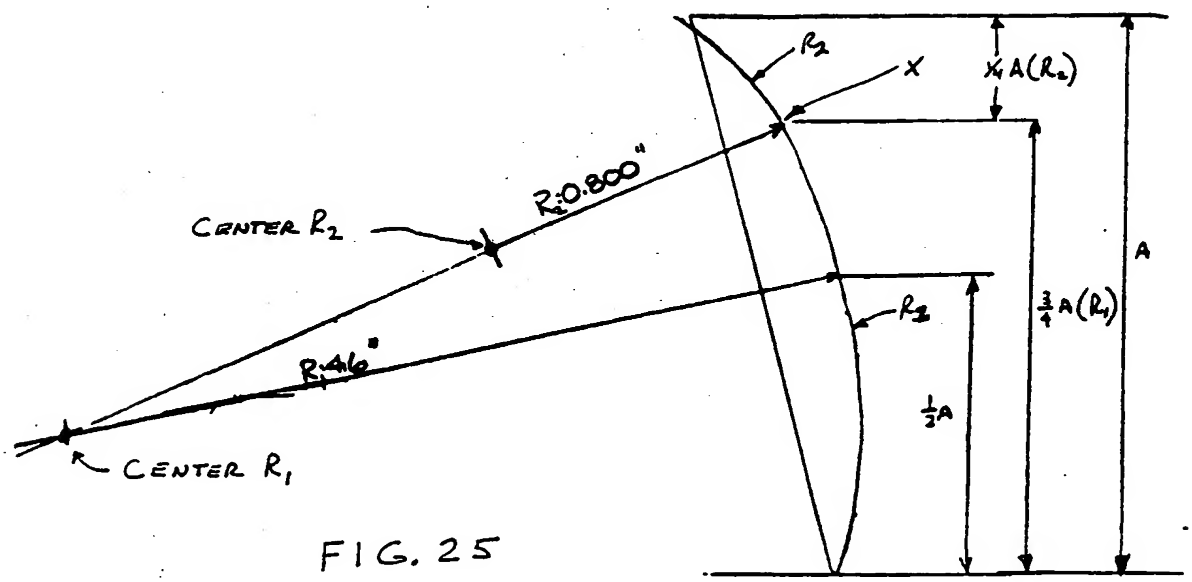

R2
X
¼A(R2)
R2:0.800"
CENTER R2
A
R1
¾A(R1)
R1 46"
½A
CENTER R1

FIG. 25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/23219

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A63B 53/04
US CL :473/330
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 473/330, 324, 331, 340, 251, 313, 290, 291, 341

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,303,923 A (GARCIA) 19, April 1994, col. 6, lines 6-19.	1-9, 11-24
Y	US 3,989,257 A (BARR) 02 November 1976, col. 3, line 36 through col. 4, line 12.	1-9. 11-24
Y	US 4,162,074 A (THOMSON) 24 July 1979, col. 2, line 61 through col. 4, line 5.	1-9, 11-24
Y	US D137,283 A (JAKOSKY) 15 February 1944, col. 1, line 8 through col. 2, line 7.	10
Y	5,624,329 A (SCHNEEBELI) 29 April 1997, col. 3, line 56 through col. 4, line 10.	10
A	US 2,023,885 A (HINCKLEY) 10, December 1935.	1-24

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
08 FEBRUARY 1999

Date of mailing of the international search report
04 MAR 1999

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
SEBASTIAN PASSANITI
Telephone No. (703) 306-3471